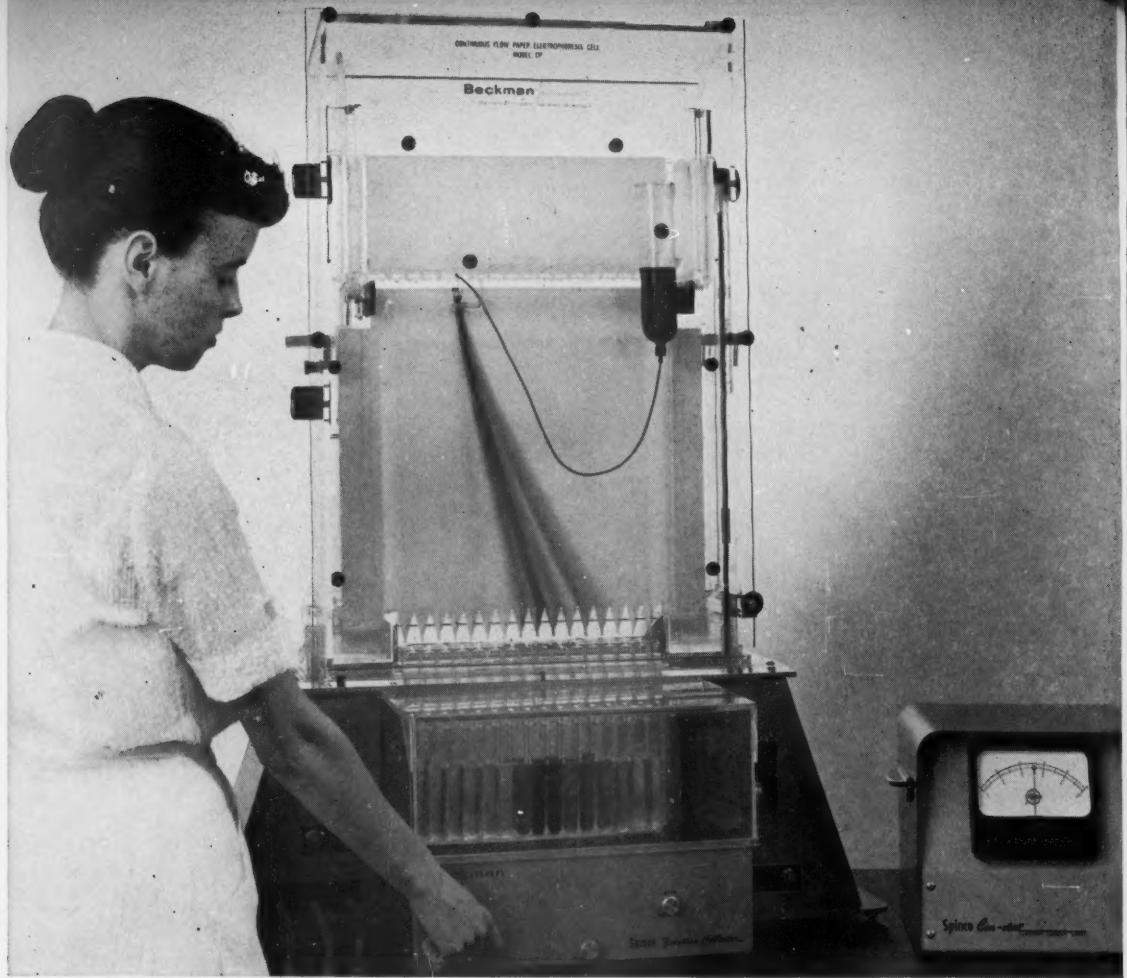


SCIENCE

M.L.
8 November 1957

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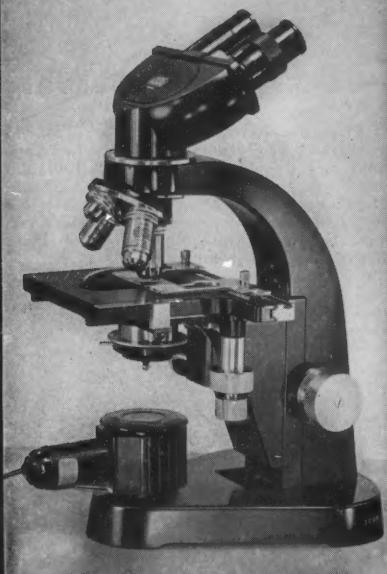
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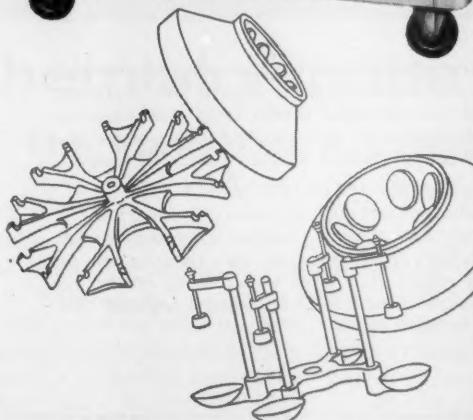


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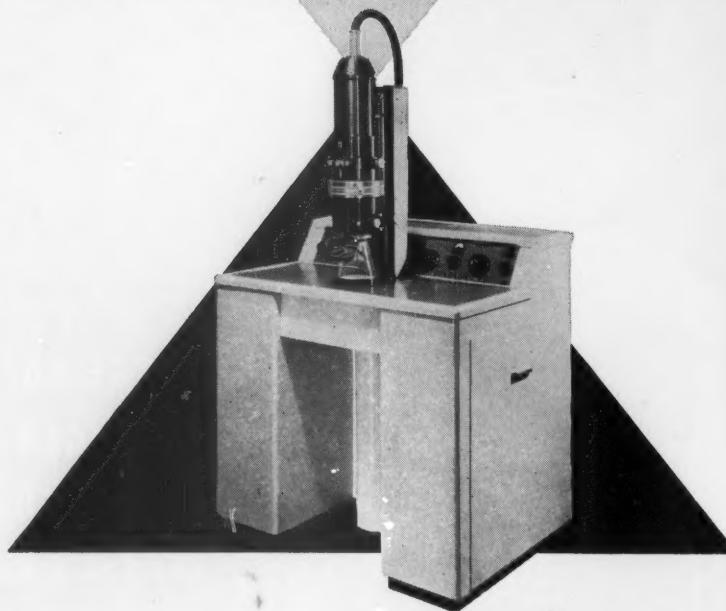
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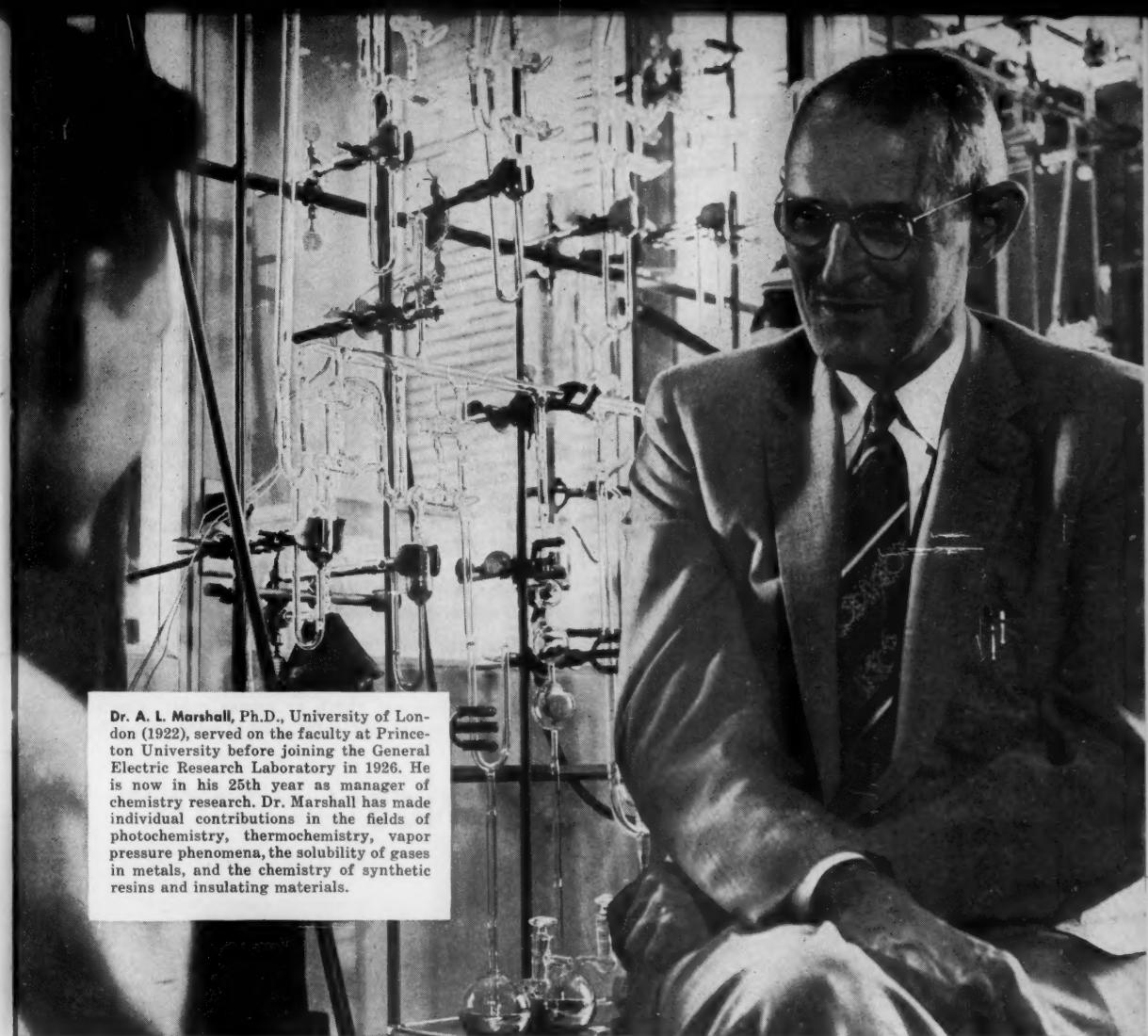
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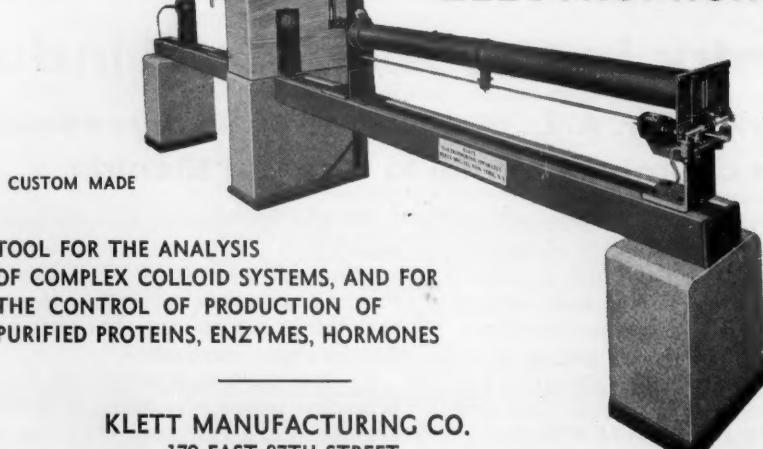
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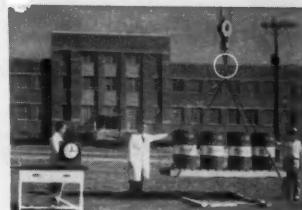
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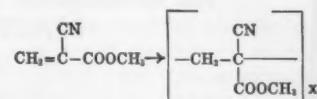


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Radio Astronomy at Green Bank

On 17 October 1957 a few hundred people gathered in the high school gymnasium at Green Bank, West Virginia, to take part in the ground-breaking ceremonies for the National Radio Astronomy Observatory. These ceremonies marked the beginning of a major effort to restore the United States to a place among the leading nations in radio astronomy as well as the culmination of a search for the most suitable site for an observatory of this kind.

The United States has lagged behind several other nations—Great Britain, the Netherlands, Australia, and the Soviet Union—in the development of radio astronomy despite the fact that radio waves of extraterrestrial origin were first detected by Karl G. Jansky, a Bell Telephone Company engineer, in this country in 1932.

The rapid progress abroad has been made possible by the construction of large radio telescopes, construction that in turn has been made possible by Government financing either directly as in the Soviet Union or indirectly as in Great Britain. In the latter country, for example, the 250-foot steerable radio telescope at Jodrell Bank was built by the University of Manchester with the aid of funds from the Government-supported University Grants Committee. In the United States, until recently, no large-scale support was available, and no instruments comparable in size to that at Jodrell Bank or to the 350-foot radio telescope in the Soviet Union have been built; the largest radio telescope in the U.S. is the 60-foot paraboloid at Harvard.

The National Science Foundation recognized that adequate facilities for research in radio astronomy were beyond the means of universities and research institutes. Accordingly the NSF, which is not an operating agency, gave a contract to Associated Universities, Inc., to select a site for, and to construct and operate, an observatory. (Associated Universities is a non-profit corporation that was formed in 1946 by nine eastern universities in order to operate Brookhaven National Laboratories under contract with the Atomic Energy Commission.)

The specifications for the site were hard to meet; the site had to be free, insofar as possible, of man-made electrical disturbances, hurricanes, and heavy snowfall. The first requirement meant that there should be no neon lights, no major power lines, no radio or television broadcasting stations and, furthermore, that none of these would be installed in the future. Extensive search showed that Green Bank was probably the most favorable site in the eastern part of the country; it has none of the man-made sources of disturbance listed above, and the surrounding mountains screen it fairly effectively from outside sources; hurricanes are a rarity; and snowfall is relatively light.

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Towards More Vivid Utopias

Margaret Mead

When one is asked to speak to a group primarily interested in the sciences from a platform defined by the humanities, it seems important to state more specifically where one's own discipline lies within the academic fields and what contribution one may expect to make from its specific interests. Anthropology holds a unique position, formally recognized in its inclusion in the National Research Council, where it belongs as a biological science; the Social Science Research Council, among those sciences which take man's biological nature as given; and the American Council of Learned Societies, because of its concern with language, so often defined as a pure humanity, without reference to the larynx or the delicate mechanism of the human ear.

This triple membership springs partly from the tradition of anthropological field work, in which single workers, with small funds and a narrow margin of time, visited, in what was conceived as probably the only careful study which would ever be made, small primitive societies whose ancient and distinctive ways of life were disintegrating even as we tried to set them down. Not only did we work with urgency, as might a student of literature, trying to take down from dictation a new poem from the lips of a dying poet, or a student of painting, who found a painter of great gift drawing in an impermanent ink on the exposed, whitewashed walls of a public square—where the rain would wash it all away tomorrow or the next day—but we also, both by the nature of the situation in which we found ourselves and by the canons of our craft, looked at the whole people, at their bodies as well as at the

social arrangements of their lives; at the music they made, or at least at the musical instruments with which they made it; at the dances, which might be seen as art to be appreciated as well as analyzed; at their rituals, which might be catalogued as *rites de passage* or regarded as an artistic product of generations of imaginative creativity, anonymous, time binding, with its own esthetic.

The anthropologist who works in this way comes to have an equal interest and respect for those aspects of human life which are concerned with the perception and ordering of observed regularities in nature and for those aspects of human life in which the "seeing eye" turns as much inward as outward, as the mind matches proprioception with perception in an outer world which already contains—in the shape of a roof, the line of a dance, the flick of a wrist at a sacrifice—the patterned perpetuation of earlier imaginative and creative acts.

Because we are also always committed to a scientific ordering of our material, these products of human imagination can not only be subjected to analysis of their function in a given society but can also be related to certain capacities of the human mind—themselves becoming better known through the imaginative scientific inquiries of investigators like Piaget and Inhelder, Gesell and Ilg, Erikson, and Margaret Lowenfeld. Delight in the imaginative creation of individuals or in the intuitive—that is, simultaneous and so unanalyzed—grasp of these as wholes by whole societies, does not prevent analytic work, also. The two methods of approach—that of the humanities, which focuses upon a recognition of the unique character of a work of the imagination, and that of the sciences, which attempt by careful observation, analysis, and finally experiment to understand the lawfulness of the behavior involved—can be used.

Vision and Cultures

It is from this particular background of research that I wish to describe the role which men's visions of a possible and more desirable future play in the development of a culture. Utopias may be seen from many points of view—as projections from individual experience; as projections from individual experiences stamped by the point of view of a particular period; as sterile blueprints, too narrow to confine the natural varieties of the human mind for very long, as when they are lived out by small cult groups who pare and mould the individuals born within them to a confining and crippling mode. Or they may be seen as those visions of future possibilities which lead the minds of men forward into the future, giving life a meaning beyond the grave or beyond the simple domestic perpetuation of one's own life in the lives of one's children, with an interest in the trees planted in one's own garden but no interest in the trees in one's neighbors' gardens. The Golden Age, a retrospective utopia of the days when all men lived like gods, and walked and talked with gods—the days before death or work or separation came into the world—may also, of course, play a significant role in keeping a whole people caught in a dream unrelated to the requirements of the contemporary world.

Using models from primitive cultures, we may, from this point of view, look at those cultures in which life is held steady by a view of the past, of which the present is a poor copy, a vale of tears where once there was Olympian laughter, at those cultures which live a hand-to-mouth existence, wrapt in the small urgencies of the present, and at those which move, generation after generation, towards Heaven—which may be the heavenly Jerusalem "with milk and honey blest," the Jerusalem to be rebuilt and rehabinited, which informed the imagination of Jews throughout the Diaspora, or the Jerusalem to be built "in England's green and pleasant land." Against these may be placed Nirvana, with its insistent comment on the lack of value in all earthly and individualized life.

Within a culture as complex as our own, which draws on the inheritance of so many earlier and partly recorded pasts and which now has available an even larger number of incomparable and imaginatively stimulating "presents,"

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from accounts of the peoples whose lives were part of a different stream—in Africa, in the Orient, and in the New World—it is obvious that we may live not only on different visions at different periods but also on different and incompatible visions at the same time. Part of the excitement and the difficulty of the modern world, which makes the artist feel that he has no whole context within which to create his personal, special new vision and which makes the scientist turn to the anonymous writing of science fiction nightmares, is just the way in which different sorts of utopias—one man's dream and another man's nightmare—jostle each other even within the confines of one political speech or one brief editorial, as we yearn for a past, rage at or delight in the present, or promise or threaten a future. While it always has been and will probably always be the mark of the more educated man that he lives in a longer time perspective, both into the past and into the future, than his less well educated contemporaries, where this education is underwritten by no habitual pattern of thought and speech within which such time perspectives are implicitly expressed, the presence of so many and such contrasting world views may seem fragmenting and mechanical rather than living.

Of Practical Import

Yet, from comparative materials, it seems quite clear that the utopias men live by are of vital importance in such mundane matters as whether they will struggle to preserve the identity of their society, their class, their religion, or their vocation; whether they will plant trees which take two lifetimes to mature; whether they will take thought to stop the forests from being depleted, the good soil from being washed into the sea, or the gene pool from becoming exposed to too much radiation. Men who believe that the ultimate good state will mean the abolition of identity are hardly likely to take an active interest in public health, and those who believe that the Day of Judgment is near, when the sheep will be separated from the goats and the whole world will go up in a holocaust directed by a punishing Deity, see the atom bomb as an addition to the Lord's armory of destruction.

Within any determinedly other-worldly religion, there is a perpetual conflict between the active acceptance of early death (so the little, innocent souls can go up to God at once, unstained by sin) and the need for public health measures and preventive medicine as well as for the compassionate dole to the beggar or care for the dying. The Catholic Church has fought a long battle against an other-worldliness which would have as its logic

an overvaluation of death—which has occasionally been the response of literal-minded savages to enthusiastic Christian preaching about heaven. On the other hand, the modern public health movement has its problems in an overvaluation of the importance of individual life, which leads to a lowering of death rates before there is a compensating rise in the standard of living and a fall in the birth rate, with the result that famine and misery are the portion of the very individuals whose lives were to be bettered.

The Pallid Utopias

At the same time, all visions of heaven, in this world and in the next, have a curiously tasteless, pale blue and pink quality, whether the image is one of cherubim and seraphim "casting down their golden crowns around the glassy sea" or of a time when "ploughs in peaceful industry shall supersede the sword," when "the dictatorship of the proletariat shall be realized in ideological completeness," or when lions shall lie down with lambs, or of a world in which women shall have been freed from all the incidental consequences of their reproductive and will spend long vacations with their lovers of the moment, flying Chinese kites.

Beside any picture of heaven above or heaven on earth, the pictures of hell and destruction stand out in vivid and compelling intensity, each detail strong enough to grip the imagination as the horrid creations of a Wells, an Orwell, or an Aldous Huxley unroll before our horrified eyes. Where positive utopias are insipid and a detailed heaven is unbearable to think of as a permanent abode, the creators of terror, the repudiators of man's future, have no such problem. So, if utopian visions are the stuff by which men live, it would seem a legitimate sub-

ject of inquiry to ask what is the matter with them? Why is Hell always so much more vivid than Heaven? Why, as I heard a young priest say recently, are all images of heaven "while not exactly not true, not as true as they might be"?

There have been attempts to give scientific answers to this question: that the prefiguration of bliss lies in the womb, where the child has no chance to use its distance receptors, and so the feeling remains one of undifferentiated and unspecified ecstasy; that analysis destroys a vision by introducing an element of self-consciousness and detachment of part of the self. These may be adequate explanations of the way in which the individual, in terms of his life experience, seeks for or experiences visionary ecstasy, but they seem insufficient answers to the problem of why the imagination of the human race, which has produced its long procession of great creations, has never yet succeeded in building a picture of a future really unlike the present, either in this world or in the next, where anyone passionately wished to live except when it was counterpointed against a Hell, delineated with the greatest precision. Heaven and all the pallid utopias are, in fact, even like Nirvana, blank white spaces—or spaces a little tinted with pastel and furnished with plastic gadgets—and are given reality only by contrast with the fear, pain, and agony of some other state.

Yet it is by visions of a better world or place or state that men make positive efforts—in contrast to fiddling while Rome burns or refraining from evil all their days in fear of hell-fire. So it would seem legitimate to ask why human imaginations are, apparently, so handicapped in the creation of such essential visions and whether there is any way in which our present scientific knowledge of human behavior and/or the way in which societies function can be used to create conditions within which utopias might be created whose positive hold on men's minds would be stronger than the negative hold of the Infernos and Lost Paradises. For the last 50 years we have experimented with the compelling character of negative images, as the prophecies of the dangers of modern warfare have grown ever sharper. When warfare is upon them, men will struggle; but they sink into a kind of paralysis when there is need to fight even harder—in peacetime—to prevent a recurrence of war. We need more vivid utopias.

One answer to the question comes from an examination of the struggle that institutionalized religions, which present the other world as desirable, must go through to deal with suicide, either condemning it as a dereliction in stewardship, as Christianity does, and treating the living out of life on earth as a trust, or hedging it around with terribly diffi-

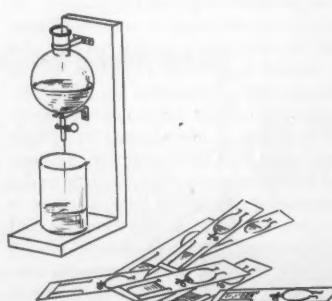


Fig. 1. Demonstration apparatus and scrambled cards from part I of Flowing Liquid Test in which a simple sequence of cards showing correct relationships is presented. [From the experimental work of Barbel Inhelder, in the Laboratory of Jean Piaget, Institut des Sciences de L'Education, University of Geneva.]

cult steps, as in parts of India, where, in order to die a holy and self-elected death, a man must give up caste and family and must become purified until, at last, dressed for the next world and in a trance, he is lowered into the earth "alive." The next world must not be so desirable that it completely competes with this one and leads a majority of believers to suicide or towards a too-willing death in war, with the promise of a warriors' heaven. A long life of preparation—as a shaven and dedicated celibate, completely cloistered or moving through the streets with a begging bowl and making a contribution to the ongoing life of the world as teacher, nurse, or supplicant—this is feasible.

Similarly, Communism has always had difficulties with those who, regarding the Soviet Union as heaven on earth, have wished to go and live there instead of remaining in their own unregenerate countries, working at dull organizational jobs in the hope of a World Revolution which they themselves might not live to see. Sometimes short trips to the Soviet Union, as circumscribed as visions of the next world to a cloistered religious, were permitted. But the tension between the vision and the present must not include any way of immediately slackening it by a self-elected entry into heaven.

Dreams—Compelling and Tempered

In fact, through the emphasis on dedication, attention is shifted from the self to the fate of others; through prayer for the souls in purgatory, teaching the young, or preparing for the revolution from which others will benefit, the necessary distance seems to be created so that a vision can be compelling, drawing one like a magnet, but not too fast or too far. So perhaps it may be said that it is only when the visionary or the prophet, the poet or the painter wants to involve the individual directly in the future vision that the danger of immediate response is allowed for in the interpreters and spectators by a dilution of its intensity. Then Heaven or the Perfect Socialist State may be seen as being too insipid and as tasting like sawdust. A feeling of less involvement may be achieved by concentrating the individual's effort on the relation between someone else and the desired state—where the nexus can have both the intensity of devotion to the other and devotion to the dream without the temptation to relax and try to get there oneself.

Even here the other temptation—to force history at once to disgorge a visionary paradise at no matter what cost of suffering and death—is present as soon as Heaven is too vividly conceived even for the other, who must then be saved, by the rack or by brain washing, to be-

come a denizen of someone else's too compelling dream. The ability of any people to cultivate protective devices against other people's compelling visions—against which the best defenses seem to be either laughter or else revolt against any individual being in thrall to the will of another—must also be considered as one component in their ability to create utopian dreams which inspire but do not limit them.

Appeal to Universals

But there seems also to be another explanation of the relative lack of vividness of the good vision as compared with the nightmare. In pictures of Hell, of dictatorships armed with concentration camps and thought control, the appeal is made to human beings' most shared and least differentiated responses; pain, hunger, thirst, being bound, tortured, cut off from other human beings, and battered day and night by intolerable stimuli—these are experiences which repel every human being and under which the savage and the civilized, the illiterate and the scholar ultimately break down.

Men of different temperaments will break in different ways and at different points, but the effect of Medieval images of the tortures of Hell, when conjured up by a gifted preacher, or of the tortures actually administered in Nazi and Communist prisons is, in the end, to break all but the exceptional martyr sustained by a vision (which, only in this exceptional situation, cannot be called too vivid) of another world to which he is personally totally committed. (So Jehovah's Witnesses are said to stand up well to Communist pressures, and Orthodox Jews went chanting to the gas chambers as the early Christians, in the days when the Second Coming was felt to be very near, faced the lions.)

Appeal to Diversity

But the utopian vision, which is vivid enough to compel men's imagination and yet not so compelling that men must resort to rack and torture to bring others into it—the vision which men want to share with others and entrust to their expanding imagination rather than the vision in which they wish to entrap and imprison others—is built not upon the universals of fear and pain, hunger and thirst, ultimate fatigue and weakness, but upon the great diversity of human propensities and gifts. It must be, in terms of modern information theory, redundant enough to catch the developed imagination of each so-different member of any society.

Reduction to fear and pain gives men a common basis of the unbearable which

can be elaborated—a nightmare peopled with Sisyphus endlessly rolling his stone and Tityus in agony. But reduction to our common good human experience leaves us with images of milk and honey, which stand very little elaboration before they are disintegrated by the involvement of our specific imaginations, by the differences in our childhood images of love and trust and bliss: it was not honey but strawberry jam, not the hum of bees but the flash of dragonfly wings, not a pointed breast but a round one which gave one suck. The recitation of such particular delights of food and drink as goat's milk or palm wine, durian, or witchetty grubs only resonate in the minds of those who once drank or ate them and fall dead upon the ears of those who never knew these pleasures. A whole society can be drawn on only by a utopian vision which contains the separate experiences of different regions, different classes, and different vocations, combined with the varied notes on each theme played by men of different temperament, disciplined and shaped by the prevailing forms of the culture. So it is no wonder that utopias are hard to come by.

The World's Needs

Yet the world today is sorely in need of a vision which will endow our lives with meaning and responsibility and will make safe the terrible powers of destruction and the almost limitless powers of construction which scientific research has put into our hands. We can specify some of the characteristics this vision must have: it must be vivid enough to compel the heart, but not so vivid that one moves too quickly, by death or emigration or the coercion of others, to attain it; it must be so conceived that it is sought for the sake of others rather than solely for the self—for other men, for the whole next generation, or for men eons ahead—with nice adjustments which make it not too immediate (just the next generation) and not too distant, lest one become lost in world without imaginable relation to the present; and it must be complex, redundant enough to catch and hold the imaginations of men and women of many different types of temperament and experience, and stylized enough, in terms of culture and period, to carry the weight of past ages of formal esthetic moulding and polishing and to speak with cadences and lines grown powerful by long usage.

These prescriptions I am giving are of the sort which can be derived from the scientific comparison of cultures; they are prescriptions for conditions. So one may compare ages and countries in which a particular art or science has flourished with those in which they have



Fig. 2. A child beginning the Flowing Liquid Test.

not so flourished, dissect out what appear to be the facilitating conditions, list and describe them.

Possibly all these may be necessary but not sufficient causes. Yet it is by the specification and attempted realization of conditions within which events desired and deemed necessary may occur that the sciences that deal with man can work in the world, stating conditions within which a child can grow, an idea can take root, an institution can flourish, and a man's hand and eye can grow cunning, his mind sharp, and his imagination wide. Though we remain dependent upon the caliber of individuals for our great achievements, the contrasts between one culture and another—between peoples whose every movement is a work of art and peoples, of the same human species, who limit their artistry to a few scratches on the edge of a pot—leave little doubt that the cultural conditions for any kind of creativity are very important. And as, by the scientific comparative study of cultures, we learn more about them, we can turn from hand-wringing, viewing with alarm, and the role of Cassandra to build the world closer to our heart's desire.

Necessary Conditions

What, then, may the conditions be within which we may foster more vivid utopias? Three resources which seem accessible to us with our present knowledge are these: the imaginations of little children, where each newborn child brings a unique and new potential to our perception and ordering of the world; the provision of materials from other cultures, so that in the interplay between the great achievements of the human race in the many separate, unique, but comparable

cultures men have built, new combinations and forms may occur; and the creation of conditions within which those who know the possibilities for the future, which are emerging from scientific discoveries, can combine their insights with the insights of those who know the full and astounding range of what man has achieved in the past, without mutations or the hypertrophies of extrasensory perception currently invoked by the creators of our folklore of the future, the writers of science fiction.

The Child's Perception

The imaginative capacities of young children, initially part of the processes of growth and evolution, as Edith Cobb has phrased it, are then one source to which we must turn. Within the growing child, the capacity to bring order out of the perception of the outside world and the capacity to create something unique and new out of his perception of himself in the world are, initially, two parts of one process. Concentration on one at the ex-

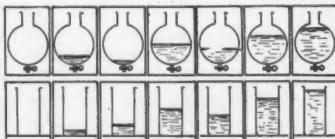


Fig. 3. A "poetic" answer to part II of the test, when the child is presented with a double set of cards. This answer, made by a boy of 5 years and 8 months of age, is described by the experimenter as containing "some mistakes characteristic of children of this age." Note the complexity of the rhyming, like a Bach two-part invention.

pense of the other robs the child, and so the world, of what could have come from both.

The current experiments of Jean Piaget and Barbel Inhelder, in Geneva, provide a vivid illustration of these two approaches. Piaget and Inhelder have developed a set of experiments to test the child's growing capacity to recognize some of the principles essential to scientific thought. One of these, which Piaget calls "reversibility," is exemplified in the child's recognition that when a large, round lump of clay is thinned out to a narrow cylinder, it will still have the same weight and be the same amount of clay. When these experiments are reported only in words, with the emphasis placed upon growth, with chronological age and school training, of the ability to recognize such points, the *other* things the child does are catalogued simply as failure. But when a method of reporting is used which records the entire behavior of children at different ages—through sound film, film and tape, or the verbatim recording of words—then the whole child comes into the picture and we see something else.

Thus, in the test situation (Figs. 1 and 2), the child is presented with a laboratory apparatus by which a colored fluid can be released gradually from the upper glass chamber, through a cock, into a glass below. The child is shown how this works and is allowed to try it. Then he is given series of cards picturing the state of the apparatus before any fluid enters the glass, at various stages, and, finally, when all of it has entered the glass. The card series are presented to the child in a scrambled state, and the child is asked to arrange them. One little boy, whose achievement on the test—like that of many children of his age—would have been reported as "failure," made a response which can be described as poetic (Fig. 3) as he "rhymed" the cards instead of arranging them to represent the reality of colored water passing into a glass in an orderly way (Fig. 4). Using the same materials, he drew on another capacity of his mind. Had this been a class in "design" or in "making pleasing patterns," his answer would have been the "right" answer, whereas when he was being tested for ability to use a kind of thinking basic to modern science, it was a "wrong" answer.

In the kind of training given in European schools of the Swiss type, the child has to learn to handle this kind of reversibility after first encountering a world in which rigid one-way sequences in behavior and among material things have been heavily emphasized. By contrast, it is the problem of how to handle rigid sequences—which cannot be reversed in fact, however they may be reversed in thought—that must be learned by the first generation of a people who encoun-

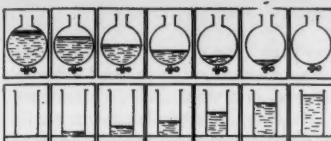


Fig. 4. The correct answer to part II of the test.

ter factory methods, people who have arranged life in their heads in poetic patterns and who have not been told that this is the "wrong" answer. Recently I saw a group of educated men and women who had been presented with some simple problems in building manifolds by means of brightly colored units; the men classified the exercise as "art" and, although they were much better in mathematics and science in college than the women, failed, while the women, who also classified the exercise as "art," at which they thought themselves good, succeeded easily. By failing to cultivate both sides of the child's ability, by opposing them and negating one or the other, we are losing not only artists but also scientists, and we are splitting our society, as well as our individual children, into incompatible parts, destructively at war with each other. A different type of education, which recognizes the early stage in which children can apprehend form through color and kinesthetic feel and the recognition of sets, is a precondition for preserving the creativity with which each generation of newborn children enters the world.

A Whole View of the Past

The second necessary condition, a knowledge of what men have done before, again involves the presentation of

wholes—not the current split between the history of science and technology, on the one hand, and art museums and literature courses, on the other. In real life the imagination of the painter and the poet are essential to the conditions within which the scientist works, for the fearful presage of the poet reaches ahead of invention. A few years ago an attempt was made to design an exhibition which would show the effect upon painting of modern scientific invention in building design; but in looking at the materials it was discovered that in every case the painter's vision had preceded the necessary technological invention, as the myth of Icarus preceded the Wright brothers. So we need arrangements which will bring together, for the experience of the student and the adult, whole historic periods—their buildings and their ideas, their books and their economics, their painting and their technology, their mathematics and their poetry—so that out of the perceived relationships and comparisons among them new ideas may be born and the present ignorance among scientists of man's past and present greatness, surpassed only by the ignorance among most humanists and many artists of man's future, made possible by science, may be overcome.

"Chairs of the Future"

Finally, it seems to me, in this age when the very survival of the human race and possibly of all living creatures depends upon our having a vision of the future for others which will command our deepest commitment, we need in our universities, which must change and grow with the world, not only chairs of history and comparative linguistics, of literature and art—which deal with the past and sometimes with the present—

but we need also Chairs of the *Futuré*, chairs for those who will devote themselves, with all the necessary scholarship and attention, to developing science to the full extent of its possibilities for the future, and who will devote themselves as faithfully to the fine detail of what man might very well—in the light of all our knowledge—be as any classicist or medievalist devotes himself to the texts of Pindar and Horace or to the thought of St. Thomas Aquinas.

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Molecular Growth Requirements of Single Mammalian Cells

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A technique developed in our laboratory for plating single mammalian cells in petri dishes containing nutrient medium permits each cell to grow in isolation to form a macroscopic colony (1-3). The method is comparable, both

in simplicity and accuracy, to the standard agar plating procedure of quantitative bacteriology. It has been used for demonstration of the existence of mutant human cell strains and for the isolation of clonal cell lines with stable differenti-

ating characteristics (4). It has provided accurate and reproducible analysis of growth curves of single mammalian cells under a variety of conditions (1-3) and has made possible quantitative studies of the action on them of agents such as ionizing radiation (5), antibodies, drugs, and hormones (6). This article (7) describes the application of this method to study of the molecular growth requirements of mammalian cells.

Procedure and Results

These experiments were carried out with the S3 clonal strain of the HeLa cell (1). Elegant studies on massive populations of the parental HeLa strain

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have been published by Eagle and his colleagues (8), who reported that the organic nutritional needs of these cells, as of other cells of human origin, were satisfied in mass culture by a medium containing 13 amino acids, eight vitamins, and glucose, supplemented with the dialyzed macromolecular portion of human serum in an amount equivalent to 10 percent of whole serum. Our own studies with single cells have revealed some interesting differences from the behavior of large populations and have shown that the molecular requirements for growth displayed by human cells may vary tremendously, depending on a variety of conditions, some of which it is the purpose of this article to delineate.

In an earlier publication we demonstrated that interaction between cells in a large population could relieve the need for a specific molecular species in the growth of a given cell type. Thus, the

Table 1. Composition of the basal synthetic medium which has been used in the experiments. This solution is diluted to 40 percent in the final medium, which also contains serum components and any other growth factors which may be desired. Final adjustment of the volume is made with Hank's saline.

Component	Amount (g/lit)
L-Arginine	0.0375
L-Aspartic acid	0.0300
L-Cystine	0.0075
L-Glutamic acid	0.0750
Glycine	0.100
L-Histidine	0.0375
DL-Isoleucine	0.0250
L-Leucine	0.0250
L-Lysine	0.0800
L-Methionine	0.0250
β -Phenyl-L-alanine	0.0250
L-Proline	0.0250
L-Threonine	0.0375
L-Tryptophan	0.0200
L-Tyrosine	0.0400
DL-Valine	0.0500
Biotin	0.00010
Calcium pantothenate	0.0030
Choline	0.0030
Folic acid	0.00010
Niacinamide	0.0030
Pyridoxine	0.00050
Riboflavin	0.00050
Thiamin	0.0050
Glutamine	0.200
Hypoxanthine	0.0250
Glucose	1.20
Phenol red	0.0125
NaCl	7.00
KCl	0.20
CaCl ₂ · 2H ₂ O	0.14
MgCl ₂ · 6H ₂ O	0.10
Na ₂ HPO ₄	0.23
KH ₂ PO ₄	0.10
NaHCO ₃	2.24
Penicillin	0.250
Streptomycin	0.250

HeLa S3 strain requires inositol when it is plated as single cells on a petri dish, but it grows with 100-percent efficiency and maximal growth rate in the absence of inositol if it is plated on top of S3 cells whose own reproductive capacity has been previously inactivated by x-irradiation (9). Similarly, we have shown that media sufficient to promote growth for many months of human fibroblastic cells in massive culture are incapable of promoting colony formation when isolated cells are plated unless a feeder layer, or enriching nutrient substances, is supplied (3).

Earlier experiments from our laboratory also have demonstrated the genetic heterogeneity of standard tissue-culture stocks and have revealed that clonal cell strains which show marked differences in their nutritional requirements, when they are grown as single cells (4) can be isolated from these stocks. These differences have maintained themselves in the respective stocks throughout continuous cultivation in the same medium for several years and for hundreds of generations. While the nutritional requirements of single HeLa cells of the S1 clonal stock are distinctly different from those of S3, and from the parental HeLa culture, which seems to contain a preponderance of S3-like forms, evidence was presented that these differences may be masked in massive cultures. When stocks which consist of mixtures of genetic constitutions are employed, the composition of the different genotypes in the population may be expected to change in the course of time in any particular laboratory, and along different paths in laboratories which originally began with the same population, because of the different selection processes that may operate in different places.

The basal synthetic medium used in all of our experiments (2, 3) is shown in Table 1 and includes the components designated by Eagle as essential. Routine cultivation of our cells is carried out in this basal medium, supplemented with 16 percent human serum and 8 percent horse serum. Experiments revealed that the basal synthetic medium of Table 1 is adequate for growth into colonies of single S3 cells if it is supplemented with 10 to 20 percent of whole human serum, or with the dialyzed, macromolecular portion of serum. In the latter case, however, the effectiveness of the resulting medium was found to be sharply dependent on the dialysis procedure employed. Dialysis of fresh human serum against Hank's saline for moderate periods of time (3 to 4 hours) results in a macromolecular preparation whose potency in supporting cell growth, when it is added to the basal medium, approximates that of whole serum. However, if fresh human serum is subjected to prolonged dialysis,

accompanied by several changes of the external medium, or if an aged serum is employed in a mild dialysis procedure, the resulting macromolecular material loses its ability to confer growth potency to the basal synthetic medium described (Table 2).

Table 2. Demonstration that prolonged dialysis of human serum results in loss of its ability to render the synthetic nutrient solution (Table 1) capable of supporting growth of S3 cells. Human serum was placed inside a cellophane bag and dialyzed with rapid agitation against nine volumes of Hank's saline for 4 hours, a period sufficient to produce equilibration of free, small molecules throughout the aqueous phase. A sample of the macromolecular portion was withdrawn, a fresh charge of saline was placed outside the bag, and dialysis was repeated. Five successive dialysis operations of this kind were performed, and the corresponding samples of the macromolecular portion of serum were then tested for their ability to promote the growth of S3 cells when added to the synthetic solution described in Table 1.

No. of standard dialyses to which the serum protein was subjected	Plating efficiency (Percentage of cells yielding colonies of 100 or more cells after 14 days' incubation in 5% CO ₂)
0 (whole serum)	83
1	74
2	0
3	0

Table 3. Composition of the supplement to the nutrients listed in Table 1, which can produce growth of single S3 cells, even when the macromolecular serum constituents have been subjected to excessive dialysis. All of these materials have been incorporated in mixtures proposed for cultivation of various cell types, and in particular, in the medium, NCTC (108) (10, 15).

Component	Amount (mg/100 ml)
Cholesterol*	0.08
Ascorbic acid	2.0
Coenzyme A	0.10
Co-carboxylase	0.04
Diphosphopyridine nucleotide	0.04
Flavinadenine dinucleotide	0.04
Glutathione	0.40
Cysteine	10.0

* Cholesterol was employed as an aqueous suspension dispersed by means of Tween 80 and alcohol, in accordance with the procedure of Earle and his colleagues (10). The final growth medium contained 0.04 mg of Tween 80 per liter. Tween alone was not effective.

Experiments were initiated to determine whether growth competence could be restored to such preparations by the addition of defined molecular species. The test was carried out first on various substances known to be important in mammalian metabolic reactions, and some of which have been routinely incorporated into solutions designed to support cell growth in tissue culture (10, 11). Such experiments revealed that growth competence which has been lost by prolonged dialysis can be restored by the addition of specific nitriles to the medium.

The number of different molecular species required to restore growth to such a medium varies with the serum specimen employed and its treatment. However, a solution containing the ingredients listed in Table 3 was found uniformly to produce growth of single cells, even after repeated dialyses.

While this supplementary group of molecules appears sufficient to restore growth competence to any batch of serum macromolecules of our experience, not all of these additional substances are equally necessary, some appearing to lend only small support, and others perhaps functioning only to offset other imbalances present in the medium (12).

However, the case of cholesterol is of especial interest. The need for this substance is usually one of the first to be revealed when the serum macromolecules are exhaustively dialyzed, and often a considerable degree of growth sufficiency can be restored by addition of the cholesterol-Tween suspension alone. Figure 1 illustrates the appearance of a plate seeded with 100 single cells which were grown in the presence of cholesterol. In the absence of cholesterol, a virtually blank plate results. This effect can be quantitatively titrated by adding to a series of identical plates varying amounts of the standard cholesterol suspension. A typical curve so obtained is exhibited in Fig. 2; it resembles the relationships obtained in bio-assay procedures with bacterial cells.

Discussion

The simplest explanation of these results is that the serum proteins tightly bind small molecular substances which are essential for growth of cells such as we have studied. Prolonged dialysis, possibly accompanied by some denaturation, releases the molecules which then must be supplied from external sources. One of the functions of serum proteins in supporting growth of cells *in vitro* would thus appear to serve as a reservoir of such essential, small molecules. Recent experiments (12a) have shown that the macromolecular constituents of serum

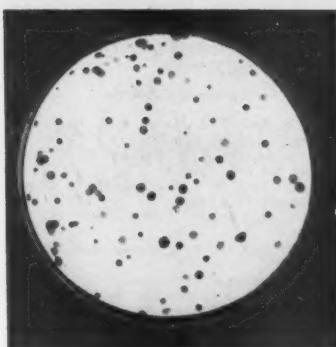


Fig. 1. Demonstration that the addition of a Tween 80-alcohol suspension of cholesterol restores to a highly dialyzed serum the ability to support growth of S3 cells. One hundred S3 cells were added to each of a series of plates containing the medium listed in Table 1, to which was also added ascorbic acid, coenzyme A, and co-carboxylase as in Table 3, and a highly dialyzed preparation of the macromolecular constituents of serum, in an amount equivalent to 15 percent of whole serum. The plate shown received a Tween-alcohol cholesterol suspension in an amount to make the final cholesterol concentration 2 micrograms per milliliter. The plates were fixed and stained after 10 days of incubation. On three identical plates with cholesterol, 105, 104, and 103 well-defined colonies appeared. On three similar plates without cholesterol, the counts were 0, 2, and 1, respectively, and these colonies were so small that they were barely visible.

needed for growth of single S3 cells include albumin, which strongly binds small molecules, and a globulin fraction exhibiting a single electrophoretic peak with a mobility of -4.4×10^{-5} square centimeters per second, per volt at pH 8.5.

These experiments illustrate how single-cell techniques can be used to uncover nutritional needs of mammalian cells, needs which are not readily demonstrable by other methods. They also demonstrate how the apparent molecular growth requirements of a given cell may be greatly influenced by the experimental conditions. The ability of cells growing in close juxtaposition to one another to exert strong influences on one another's growth was emphasized by Earle and his co-workers (13) and demonstrated in specific ways by our own experiments on feeder cell systems (9). The mechanism by which a cell growing in a community can dispense with certain molecules essential for growth of single cells constitutes a problem of fundamental importance. It is possible, as Earle has suggested, that all or most cells possess minimal biosynthetic capacities for many molecules which are lost too rapidly from isolated cells to permit initia-

tion of cell reproduction. Moreover, the permeability of cells closely packed in a colonial array may conceivably be markedly different from that characteristic of isolated cells. These considerations could also explain the much greater difficulty exhibited in obtaining growth of fibroblastic, as compared with epithelial-like, cells (3), for the more highly stretched condition of the former exposes more surface, and their greater tendency to form loose, open meshworks, instead of tight, compact masses, would encourage greater loss of diffusible, essential metabolites.

Other factors also can exert strong influences on the apparent growth requirements of mammalian cells. One of these is the incubation period which is permitted for colonial development of single cells. Often a medium will seem adequate for growth, permitting colony formation to the number of 50 or even 100 cells. On continued incubation, however, the number of cells per colony will become stationary and then will fall, as the cells begin to disintegrate. Results of this type are undoubtedly influenced by the cells' ability to store large quantities of needed metabolites. We have also found that the medium of previous cultivation can profoundly influence experiments testing the growth of single cells. Finally, we have observed that certain molecules appear to be necessary for growth of single cells only when other substances are also included in the medium, an indication of the need to maintain certain metabolic balances (14).

Summary

The molecular nutritional requirements exhibited by mammalian cells can vary with the following conditions: whether the cells are plated singly or in massive inoculum; whether a clonal strain or a mixture of different genotypes is employed; whether the macromolecular fraction of serum used as a supplement was previously exposed to pro-

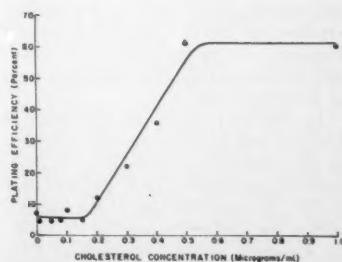


Fig. 2. Titration curve showing the quantitative relationship between the plating efficiency of single HeLa S3 cells and the amount of cholesterol-Tween 80 suspension added.

longed dialysis or other procedures which may release bound micromolecules. In addition, the nature of the medium in which the cells were previously grown, the time permitted for incubation of the cells in the test medium, and the presence of substances or conditions which may specifically introduce the need for certain molecules to preserve balance can strongly influence nutritional requirements. This great versatility may reflect the ability of the mammalian cell to assume different metabolic states characteristic of specific types of differentiation. Under certain conditions,

growth of single HeLa cells of the S3 clonal strain requires the presence of cholesterol at a level of 0.5 to 1 microgram per milliliter.

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E. S. G. Barron, Medical Biochemist

E. S. Guzman Barron, professor of biochemistry in the Department of Medicine at the University of Chicago, died 26 June 1957, at the age of 58. He leaves a host of friends in science, scattered throughout the world. He was educated in Peru, his native country, and completed his medical education at the University of San Marcos at Lima, in 1924. He then spent 2 years of study in Paris and Strassburg. In 1927 he came to the United States to work with the late Leonor Michaelis at the Johns Hopkins Medical School.

It was there that he began his distinguished work on the role of sulfhydryl compounds in biological systems—work that he continued throughout his career. This was also the period during which he made the original observation that nonrespiring cells, such as mammalian erythrocytes, can be converted to actively respiring cells by the addition of a suitable oxidation-reduction mediator, such as methylene blue.

In 1930 he came to the University of Chicago and became assistant professor in the Department of Medicine in 1931, associate professor in 1942, and professor in 1952. He was a member of the research staff of the Lasker Foundation for Medical Research at the University of Chicago.

During these 27 years, Barron made

pioneering and consistently significant contributions to the problem of biological oxidations. Among these were studies on the mechanism of lactic acid oxidation by bacteria, the oxidation-reduction potential of the lactate-pyruvate system, the oxidation-reduction potentials of hemochromogens, and the key position of pyruvate in intermediary metabolism. His article in *Physiological Reviews*, in 1939, on cellular oxidation systems is a classic which well merits careful study today.

Except for the war years, when he engaged in research for the Office of Scientific Research and Development, Barron made continual contributions to what we now know about intermediary metabolism of foodstuffs. His biochemistry was ultimately oriented toward the metabolic behavior of tissues and the part that individual enzyme systems play in over-all metabolism.

During and after the war, Barron actively engaged in the study of the biochemical mechanism of radiation damage. In this work he was a proponent of the important part played by sulfhydryl groups and of their modification through radiation.

Although he did little formal teaching, he had a continuous flow of post-doctoral fellows in his laboratory—men from many fields of medical science and from

many countries. His influence as a teacher of those who are today's investigators in the medical sciences was very great indeed. And, to all, he imparted the excitement of curiosity, the value of industrious documentation, and the importance of critical evaluation. His younger brother, Alberto Guzman Barron, was one of those who received inspiration and biochemical training under his guidance; he now holds the chair of biochemistry and nutrition at the University of San Marcos at Lima.

Personally, Achito, as those of us who knew him affectionately called him, was serious and single-minded in all his scientific activities, but apart from these, he was gay and full of the joy of living.

He loved Woods Hole and always spent his summers there, where he was a trustee of the Marine Biological Laboratory. As he often stated, it was through his contacts at the Marine Biological Laboratory that he broadened his outlook and received inspiration for his winter research activities.

In Peru, although he became an American citizen in 1939, he is recognized as one of the leading scientists of the country. There he has been honored by being made honorary professor of the University of San Marcos at Lima and by being awarded an honorary Doctor of Science degree, by the University of Trujillo, and the Order Del Sol.

I visited his laboratory on two occasions last spring and I found it a beehive of productive activity, with Achito the hardest worker of them all. It is tragic, indeed, that he is lost to science and to the scientific community at the height of his productivity. But still more to be regretted is the loss of his warm personality from the company of those who bore him great admiration and affection.

A. BAIRD HASTINGS
Harvard University Medical School

News of Science

Sputnik II

On 3 November the U.S.S.R. launched its second earth satellite. Reportedly shaped like a rocket and carrying a dog as passenger, Sputnik II weighs 1120.29 pounds and is traveling at a rate of about 17,840 miles an hour. It is circling the earth every 103.7 minutes in an orbit that is approximately 1056 miles out at its furthest point. Many scientists have made public statements about the latest space vehicle, and some of these comments are reproduced here.

Alan T. Waterman, director of the National Science Foundation, praised the accomplishment and said that the world would "gain valuable knowledge" from the dog-carrying satellite. He said further:

"It is now clear, as we have anticipated, that the Russians have been working with great determination on a planned series of satellite undertakings. They again deserve credit for a difficult engineering accomplishment."

Joseph Kaplan, chairman of the United States Committee for the International Geophysical Year, applauded the Soviet launching as a "significant scientific achievement." Referring to a Soviet announcement that Sputnik II is part of the U.S.S.R.'s participation in the IGY, Kaplan said:

"Preliminary information to assist all nations in tracking the satellite has already been released, and we shall accordingly look forward to a full exchange of data connected with the scientific experiments which are being conducted with the aid of this satellite."

In Japan, Masashi Miyaji, head of the Tokyo Astronomical Observatory, stated: "We are very unhappy that the Russians did not give any notice for both launchings." However an IGY spokesman reminded the Associated Press that neither the U.S.S.R. nor the United States is required by IGY agreements to give advance notice of a specific launching time.

John P. Hagen, director of the Navy's Project Vanguard, which is responsible for developing this country's satellite, said that Sputnik II and its weight came as no surprise to American sci-

tists. He warned that it was unwise "to go off the deep end and say this is a tremendously different achievement than the first launching. What they have done today doesn't change our estimate of their capabilities. They now have two gadgets in the air. We have yet to put our first up. . . . We should diligently pursue our own program—it's a well-thought-out scientific program. At the end of the Geophysical Year, we can take stock to see who has the better scientific results. I have a lot of confidence in the capability of our people."

John Rinehart, assistant director of the Smithsonian Astrophysical Observatory, headquarters for our satellite tracking organization, commented:

"No matter what we do now, the Russians will beat us to the moon. . . . I would not be surprised if the Russians reached the moon within a week." He said further that the United States has the technological skills to match the Russian satellite accomplishment and that:

"Some leader must arise and get the program highly organized to do the job. . . . I think this is sufficiently an emergency to have the entire program put under a single-type project. This is a matter of national pride. If we want to maintain the respect of the rest of the world we must do this."

J. Allen Hynek, associate director of the Smithsonian Astrophysical Observatory, did not think a moon rocket project would be undertaken by the Russians as soon as Rinehart did, but he said the launching proved the Russians certainly have the potential for firing an intercontinental ballistic missile. He went on to say: "I certainly would think its larger size means it will be more easily visible to the naked eye." Unlike Hagen, Hynek commented that the biggest surprise to him was the size of the new satellite. He said in closing: "The Russians have demonstrated that they can put an object of tremendous weight into the sky, and it looks as if they are that much closer to the ball park."

Edward Teller, associate director of the University of California Radiation Laboratory, said:

"Launching of the two satellites will not be the last of the Russian achieve-

ments. They have lived up to their boasts in the past and likely will continue to do so." Only a few hours before the launching of Sputnik II, Teller told a group of elementary-school science teachers at San Francisco State College that the U.S.S.R. might hit the moon before the week was out. He then warned: "If they surpass us in technology in the year ahead, there is very little doubt who will determine the future of the world."

Ronald Bracewell, an astronomer and associate professor of electrical engineering at Stanford University, acted as spokesman for a group of Stanford specialists when he said:

"We have come to the conclusion that this new satellite . . . will be up there for our lifetime and probably a lot longer—100 years or more."

AAAS-Campbell Award for Vegetable Research

The new AAAS-Campbell Award for Vegetable Research has just been established by the Campbell Soup Company and will be presented for the first time this year. The award consists of \$1500 and a bronze medal, given for "an outstanding single research contribution, of either fundamental or practical significance, relative to the production of vegetables, including mushrooms, for processing purposes, in the fields of horticulture, genetics, soil science, plant physiology, entomology, plant pathology, or other appropriate scientific areas." Work in food technology and work in food processing are not included; the emphasis is on basic research and its application to crop production, prior to crop utilization or crop production.

The one or more papers reporting a candidate's single research contribution should have been published, or accepted for publication, in a recognized scientific journal not more than 2 years prior to the date the award is to be granted. Competition is open to all residents of the United States and Canada. Travel expenses are provided for the recipient to attend the AAAS meetings to receive the award in person.

The Award Committee is composed of a chairman appointed by the AAAS and official representatives of six affiliated societies: the American Phytopathological Society, the American Society for Horticultural Science, the American Society of Agronomy, the American Society of Plant Physiologists, the Entomological Society of America, and the Genetics Society of America.

Members of this year's Award Committee are as follows: Louis P. Reitz (vice-president for AAAS Section O—Agriculture), USDA, Agricultural Re-

search Service, Beltsville, Md., chairman; G. J. Haeussler (Entomological Society of America), USDA, Agricultural Research Service, Beltsville, Md.; Sterling B. Hendricks (American Society of Plant Physiologists), USDA, Plant Industry Station, Beltsville, Md.; Iver J. Johnson (American Society of Agronomy), Iowa State College, Ames; F. C. Stark, Jr. (American Society for Horticultural Science), University of Maryland, College Park; G. Ledyard Stebbins, Jr. (Genetics Society of America), University of California, Davis; E. E. Wilson (American Phytopathology Society), University of California, Davis. Nominations for the Campbell Award may be made to any member of the Award Committee.

NSF Federal Manpower Report

Some 142,000 Federal employees, including 37,000 scientists and engineers, were engaged in the conduct of research and development and related activities in 1953-54, according to the National Science Foundation. The figure represents 7 percent of the total Federal personnel in that fiscal year.

In addition, 77,000 persons, or 2 percent, of all military personnel were also engaged in scientific activities. Of this total, approximately 9000 were scientists and engineers, while the rest were supporting personnel.

Conservation Fellowships

The National Wildlife Federation has announced its 1958-59 scholarships and fellowships in conservation, for which an applicant need not necessarily be enrolled at an institution of higher learning if his project or proposal has merit in the cause of conservation. Completed application forms must be postmarked on or before *31 December*. Application blanks and further information may be obtained from Ernest Swift, Executive Director, National Wildlife Federation, 232 Carroll Street, NW, Washington 12, D.C.

Aeronautical Fellowship

The Institute of the Aeronautical Sciences has announced the availability of its Flight Test Engineering Fellowship at Princeton. An applicant must be a U.S. citizen and have a bachelor's degree in engineering by June 1958. The stipend is \$4700 for a 2-year period. Applications, endorsed by a sponsor, must be mailed *before 1 March* to: Flight Test, Institute of the Aeronautical Sciences, 2 E. 64 St., New York 21, N.Y.

Jackson Imports British Mice

The Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Me., has announced that mice carrying five genes never before available in the United States were imported from England last summer and will join the main laboratory colony in the near future. These particular genes, of significant value in physiological and developmental studies and in chromosome mapping, are Hertwig's Anemia, Matted, Patch, Dilute Lethal, and Oligosyndactyl.

Due to the ever-present danger of introducing disease into the Jackson mouse colony, it is necessary that an elaborate quarantine procedure be carried out before imported animals are fully accepted. For about 8 weeks the 48 new animals were kept in special quarters well away from the Bar Harbor laboratories. There they were subjected to a series of tests that proved that they were free of ectromelia, or mouse pox, the disease most feared. Now the imported mice are in the isolation ward of Jackson Memorial's main laboratory.

Pharmacognosy Awards

Competition for the three annual \$250 Edwin L. Newcomb Memorial Awards in Pharmacognosy has been announced by the American Foundation for Pharmaceutical Education. These are open to undergraduate and graduate pharmacy students, and to teachers, research workers, and industrial scientists. Published and unpublished papers on pharmacognosy must be submitted *before 1 February* to the chairman of the Awards Committee, H. W. Youngken, Massachusetts College of Pharmacy, Boston, Mass.

Committee on Chronic Illness and Health of the Aged

Surgeon General Leroy Burney has appointed a 13-member National Advisory Committee on Chronic Illness and Health of the Aged that includes specialists in medical education, geriatrics, physical and industrial medicine, nursing, care of the aged, public health, and public welfare. The committee members will review the medical, social, and economic problems associated with illness and aging, and will consult with and advise the Surgeon General on the development of Public Health Service policy and programs in these fields.

One out of every 25 persons in the United States today has been disabled for more than 3 months with some chronic illness. Furthermore, since 1900 the number of people 45 and over has increased 3½ times. Today more than 40

million people, approximately 30 percent of the total population, are in this age group. By 1970 their number is expected to increase to 61 million. Moreover, 40 percent of the chronically ill in this country are persons 65 years of age and over, of whom there are now 14 million in the United States.

News Briefs

UNESCO has announced that the emphasis of this year's Human Rights Day, 10 December, will be on educational institutions, teachers, and other groups concerned with education. It is hoped that educationalists will help to lay the groundwork for a widespread and effective observance next year of the tenth anniversary of the adoption of the Universal Declaration of Human Rights.

* * *

The Society for the Rehabilitation of the Facial Disfigured has given New York University-Bellevue Medical Center a \$1-million grant, which was made possible by the Avalon Foundation, to put up a new Institute of Reconstructive Plastic Surgery. The institute will be located in a new 19-story hospital to be built at the Medical Center. The grant also provides for an endowed chair of plastic surgery, to be known as the Lawrence C. Bell Chair. The first incumbent will be John M. Converse, professor of surgery at N.Y.U. College of Medicine.

* * *

A new electronic company, Digital Equipment Corporation, has been established in Maynard, Mass., with the backing of the American Research and Development Corporation of Boston. The new company was organized to provide testing equipment for the U.S. computer industry. Officers include Kenneth H. Olsen, president, and Harlan E. Anderson, vice president; both have been active in the design and application of advanced computers and were staff members of the Lincoln Laboratory of the Massachusetts Institute of Technology.

Scientists in the News

GEORGE B. PEGRAM, pioneering nuclear physicist and vice president emeritus of Columbia University, has received the first Karl Taylor Compton Gold Medal of the American Institute of Physics. Presentation was made by Britain's Prince Philip in conjunction with the dedication of the institute's new building at 335 E. 45 St., New York.

ERNEST P. PICK, internationally known pharmacologist of the Merck Institute for Therapeutic Research, has received the Schmiedeberg award of the

German Pharmacological Society. Pick became associated with the Merck Institute after coming to this country in 1939. Prior to that, he was a member of the medical faculty of the University of Vienna for 34 years, and dean of its medical faculty in 1932 and 1933. At the age of 86, he is still conducting research in the Merck Laboratories.

PRINCE PHILIP, DUKE OF EDINBURGH, received the National Geographic Society's Gold Medal for service to geography during his recent visit to this country. The inscription to the Prince described him as one "whose questing spirit has taken him to the far corners of the globe and brought to millions a better understanding of our planet and its peoples."

FRED HOYLE has been appointed Addison White Greenway visiting professor of astronomy at California Institute of Technology. Each year he will spend the fall term in residence.

Other institute appointments include: C. H. E. WARREN, senior member, scientific research staff of the Royal Air Force Establishment, England, senior research fellow in aeronautics; GEORGE M. BROWN, on leave as associate professor at the University of Maryland, and EDWARD L. KING, on leave as associate professor at the University of Wisconsin, senior research fellows in chemistry; and WALTER E. MEYERHOFF, on leave as associate professor at Stanford University, senior research fellow in physics.

ALBERT R. MEAD, for the past year acting head of the department of zoology at the University of Arizona, has been appointed head of the department. In the same department, WILLIAM H. BROWN is on sabbatical leave visiting European universities.

S. ALLAN LOUGH has been appointed director of the Atomic Energy Commission's Health and Safety Laboratory in New York. Since October 1956 he has served as deputy director. He succeeds MERRILL EISENBUD, who became director in 1949. Eisenbud will continue as manager of the commission's New York office.

JOSEPH L. MELNICK, professor of epidemiology at Yale University School of Medicine, has been appointed to the staff of the Division of Biologics Standards at the National Institutes of Health, where he will serve as chief of both the Laboratory of Viral Products and the Virus Research Section. Melnick's research for the past several years has been concentrated largely in the new field of enteric viruses.

CLEMENT A. SMITH, associate professor of pediatrics at the Boston Lying-In Hospital, the Children's Hospital, and Harvard Medical School, has received the first Arvo Ylppö medal, honoring the founder of the modern practice of pediatrics in Finland. The presentation took place in Helsinki on 26 October, the 70th birthday of Dr. Ylppö, who is professor of pediatrics at Helsinki University and internationally known for his pediatric research. Smith was selected to receive the first gold medal for his basic research in the care of premature infants. Ylppö also received a gold medal during the presentation ceremonies.

The Arvo Ylppö Medal henceforth will be awarded every fifth year to both a Finnish and a foreign scientist. The recipients' contributions must be international in importance and must be related to research dealing with prematurity. Subsequent medals will be struck in silver. The award has been established by four Finnish organizations: The Mannerheim League for Child Welfare; the Finnish Pediatric Association; the Foundation for Support of Pediatric Research; and the Orion Company, manufacturers of pharmaceuticals.

ALAN T. WAGER is chairman of the new department of physics at Arizona State College. The department was created during the recent reorganization of the institution's Liberal Arts College.

At the recent National Electronics Conference in Chicago, two scientists were honored for papers presented at previous meetings. LEON BRILLOUIN, New York City science consultant, received the \$750 NEC Award of Merit for his paper on "A Theorem of Larmor and Its Importance for Electrons in Magnetic Fields," which was presented at the 1944 NEC meeting. ISAAC M. HOROWITZ of the Polytechnic Institute of Brooklyn received the \$500 NEC Annual Award for his paper on "R-C Transistor Network Synthesis," which he gave at the 1956 conference.

PAUL A. WEISS, member and professor of the Rockefeller Institute and head of the laboratory of developmental biology, recently received the 500,000th microscope made by the century-old firm of Ernst Leitz, of Germany, at a brief ceremony in his laboratory. The presentation of the microscope was in the tradition of special recognition given by the Leitz organization to internationally known scientists for fundamental contributions to the knowledge of living structures and their development and pathology. Weiss is the first American to be so honored. Robert Koch, discoverer of the tubercle bacillus and founder of modern bacteriology, received the

100,000th Leitz microscope in 1907; Paul Ehrlich, pioneer in chemotherapy, the 150,000th in 1912; Martin Heidenhain, histologist, the 200,000th in 1921; Ludwig Aschoff, founder of modern pathology, the 300,000th in 1930; and Gerhard Domagk, Nobel prize winner for chemotherapy, the 400,000th in 1949.

HUGO L. BLOMQUIST, member of the botany department at Duke University since 1920, and chairman from 1930 to 1954, has retired. In the same department, ROBERT L. WILBUR, formerly at North Carolina State College, has been named taxonomist and curator of the Vascular Herbarium.

Raytheon Manufacturing Company has announced the election of two new vice-presidents: DAVID D. COFFIN, electrical engineer and manager of the Missile Systems Division, and THOMAS H. JOHNSON, physicist and manager of the Research Division.

RICHARD G. EARNSHAW of Manchester, England, is serving as visiting associate professor of dental materials at the Northwestern University dental school. He is on a year's leave of absence as lecturer in prosthetics at the University of Manchester.

The Executive Committee of the World Meteorological Organization has just awarded posthumously to CARL G. ROSSBY of Stockholm the annual prize created to commemorate the International Meteorological Organization. Rossby, who died on 19 August 1957, was a pioneer in meteorological research. Born in Stockholm in 1898, he studied in Sweden and Norway and then in 1926 came to the United States.

In this country he worked at Massachusetts Institute of Technology, where he established a chair of meteorology that he occupied until 1939. After being scientific adviser to the American Meteorological Service (U.S. Weather Bureau), he was named professor at the University of Chicago. Beginning in 1947, Rossby has been dividing his time between his scientific work in the United States and direction of the International Meteorological Institute that he had founded in Stockholm.

ARTHUR E. RAYMOND, vice president for engineering at Douglas Aircraft Company, is to receive the 1957 Daniel Guggenheim Medal "for notable achievements in the advancement of aeronautics." The medal will be presented on 28 January 1958 during the honors night dinner of the Institute of the Aeronautical Sciences at the Hotel Sheraton-Astor, New York. Raymond is the 29th recipient of the award.

PETER FORTESCUE, a British nuclear engineer, has joined the General Atomic Division of General Dynamics Corporation, San Diego, Calif., as chief research and development engineer. In 1947 Fortescue became a member of the staff of Britain's Atomic Energy Research Establishment at Harwell. He assisted in the establishment of a laboratory to deal with a wide range of engineering problems associated with programs for power reactors and diffusion plants. This work included the development of cooling arrangements for the Calder Hall reactors.

GAELEN L. FELT, an assistant division leader in the Test Division of the University of California's Los Alamos Scientific Laboratory, has left the laboratory after an affiliation of 12 years to accept a position with the Ramo-Woolridge Corporation in Los Angeles, Calif. There he will be the Titan flight-test director of the Guided Missile Research Division. This division has responsibility for systems engineering and technical direction for the U.S. Air Force ballistic missile program, which includes the ICBM Atlas and Titan, and IRBM Thor. During past weapon tests in Nevada, Felt has been deputy test director for the joint Atomic Energy Commission-Department of Defense test organization, and at Eniwetok he was commander of a task group that conducted scientific experiments.

Staff appointments for the new department of neurology at Wayne State University College of Medicine were announced last month by JOHN S. MEYER, department chairman. Those named included: RUSSELL T. COSTELLO, clinical professor, and JACOB L. CHASON, associate professor and pathologist-in-chief.

A neurological teaching service has been established with a total of 33 neuro-medical beds: Detroit's Receiving Hospital has assigned 15 beds; Lafayette Clinic, which is adjacent to the College of Medicine science building, has established an 18-bed neurological ward. Wayne now provides the only university neurological training program in Detroit.

SIR FRANK WHITTLE, British inventor of the turbo-jet engine, has received the 1957 John Scott Medal, which includes a scroll and \$1000. The presentation was made at the United States Embassy in London, on behalf of the City Trusts of Philadelphia, trustees of the John Scott legacy.

ROBERT H. WASSERMAN, bacteriologist and animal nutritionist, has resigned as a senior scientist in the Medical Division of the Oak Ridge Institute of Nuclear Studies to accept the post of research associate at Cornell University.

WILLIAM J. MORGAN, chief of the motivation and development branch in the Office of the Chief of Staff, Department of the Army, has resigned his position in order to devote full time as a consulting psychologist for Aptitude Associates, Inc., of Merrifield, Va.

GEORGE PIMENTEL, associate professor of chemistry at the University of California, has received the seventh annual award of the California Section of the American Chemical Society for his work in infrared spectroscopy, and especially for his development of unusual techniques for the infrared study of free radicals. The purpose of the award is to recognize achievement by a chemist under 40 years of age who is a resident of one of the 11 Western states.

Recent Deaths

REGINALD M. ATWATER, Bronxville, N.Y.; 65; executive secretary of the American Public Health Association since 1935; managing editor of the *American Journal of Public Health* and special consultant to the U.S. Public Health Service; in the 1920's he was an associate professor of hygiene at Hunan-Yale College of Medicine in Changsha, China, and medical officer of the Kuling Estate in Kiangsi; 18 Oct.

GEORGE A. CLARK, Scranton, Pa.; 66; pathologist and cancer researcher who conducted investigations at the National Cancer Institute, 1930-38; 18 Oct.

SAMUEL A. DEEL, Topeka, Kan.; 79; professor of physics at Baker University, 1908 to 1939; was employed at U.S. Coast and Geodetic Survey in Washington, D.C., 1942 to 1948; 10 Sept.

J. C. JENSEN, Lincoln, Neb.; 76; physicist and pioneer in radio transmission; taught at the University of Nebraska for 42 years and retired in 1952; 19 Oct.

MORRIS S. KHARASCH, Chicago; 62; director of the Institute of Organic Chemistry at the University of Chicago; widely known for development of chemical compounds, including disinfectants; 9 Oct.

GEORGE LAWTON, New York, N.Y.; 57; psychologist, educator, and author whose writings included *Straight to the Heart*, a personal account of the thoughts and feelings of a heart-surgery patient; lecturer on adjustment and marital relations at Columbia University's School of General Studies; founder of the New York Association of Clinical Psychologists; 8 Oct.

ALFRED J. LIEBMAN, New York, N.Y.; 72; research chemist and president of the Schenley Research Institute; in World War II served as a member of

the War Production Board's penicillin producers industry advisory committee; 11 Oct.

FELIX MANDL, Vienna, Austria; 65; surgeon, cancer specialist and head of the surgical staff of Franz Joseph Hospital, Vienna; directed the Surgical College of Hadassah University in Jerusalem from 1939 to 1947; 14 Oct.

PAUL D. MERICA, Tarrytown, N.Y.; 68; metallurgist; former president, International Nickel Company of Canada, Ltd., and of the International Nickel Company, Inc., with which he had been associated since 1919; member of the National Academy of Sciences; 20 Oct.

OTTO RAHN, Millboro, Del.; 76; former professor of dairy physics and one-time head of the Preussischen Versuchs-und-Forschungsanstalt für Milchwirtschaft, Kiel, Germany; was professor of bacteriology at Cornell University; 26 Sept.

WALTER H. SCHAEFER, Marquette, Mich.; 55; physiologist, professor of biology at Northern Michigan College since 1946; also was a faculty associate at Horace H. Rackham School of Graduate Studies, University of Michigan; 14 Sept.

F. DESMOND SPRAGUE, Bennington, Vt.; 69; electrical engineer; aided in the development of railroad safety-control equipment; 8 Oct.

ARLOW B. STOUT, Pleasantville, N.Y.; 81; botanist, curator emeritus of the New York Botanical Garden, which he joined as a director of laboratories in 1911; specialist in experimental studies on the nature and genetics of intra-specific self and cross incompatibilities in the sexual reproduction of flowering plants; 12 Oct.

GEORGE M. STRATTON, Berkeley, Calif.; 92; founder of the University of California's department of psychology and for many years its chairman; professor emeritus of psychology since 1935; known for his experiments involving the wearing of eyeglasses with lenses that inverted the image to study human adjustment to suddenly reversed perception; member of the National Academy of Sciences; 9 Oct.

ARCHIE THORNTON, Poughkeepsie, N.Y.; 63; writer on horticulture; instructor at New York Botanical Garden in 1956; 19 Oct.

R. L. WESTHAFFER; professor of mathematics at New Mexico College of Agriculture and Mechanic Arts; past president of the Southwestern Division of the American Mathematical Society; 5 July.

DE FOREST P. WILLARD, Sea Island, Ga.; 73; former professor of orthopedics in the Graduate School of Medicine at the University of Pennsylvania; a past president of the American Orthopedic Association; 3 Oct.

Reports

Incidence of Marine Fungi in Relation to Wood-Borer Attack

The destruction of wood, when it is submerged continuously or intermittently in the sea, by isopod gribbles and teredine borers is well known. Various investigations have been made of the dynamics of attack and of the individual organisms involved. However, there is comparatively little information about the biological and physical agents that act upon the submerged wood substrate prior to the borer attack. One group of marine organisms that warrants serious consideration in this respect is that of the wood-inhabiting fungi, especially the Ascomycetes and the Fungi Imperfecti.

While our knowledge of marine fungi in general has increased considerably within the past 10 years, no intensive investigation has been made of the possible association of these fungi with the activity of wood-boring animals. However, it has been postulated that fungi may participate in a "conditioning" of the wood before attack by borers (1).

Since 1952, the Marine Laboratory of the University of Miami has been engaged in marine mycological studies (2), including numerous investigations of the distribution of fungi in Biscayne Bay, Florida, the Caribbean Sea, the Bahamas, the Gulf of Mexico, and at more than 63 stations throughout the United States, Canada, Alaska, Nova Scotia, Newfoundland, and the Canal Zone.

The collections and studies have involved different woods (primarily southern yellow pine and basswood), various seasons of exposure and lengths of submergence, and selected samplings within specific localities. The period of tests in boreal and northern temperate areas included the winter months, primarily from October through February, when borer

activity is negligible and often completely absent. Hence, over this submergence period, with the factor of borer damage naturally limited, we have been able to examine the occurrence and extent of fungal infestation operating independently of marine borers. Two common gribbles, *Limnoria lignorum*, a boreal form, and *L. tripunctata*, an inhabitant of temperate areas, both have maximum activity at seasons of elevated temperature, usually beginning in the early spring (3). Similarly, the spawning of *Teredo navalis*, a widely distributed teredine borer, is activated at 11° or 12°C (4).

The following pertinent observations should be noted especially. (i) Fungal infestation of wood occurs at all our test localities, varying in intensity and in different genera and species involved. Species of *Lulworthia* and *Helicoma* are extremely abundant, colonizing wood at the majority of the stations. (ii) Vigorous attack upon submerged wood in boreal and northern temperate areas during winter months is accompanied by no, or very slight, borer damage. A similar situation occurs in subtropical localities, however, with a considerably shorter period of fungal attack prior to borer infestation. In Biscayne Bay, Florida, vigorous sporulation by ascomycetous fungi occurred on wood that had been submerged for approximately 2 to 3 weeks.

In addition to being manifested by the presence of surface and imbedded ascocarps and conidia, fungal infestation is also manifested through (i) softening and disintegration of the outer wood tissues, often to a depth of several millimeters, (ii) proliferation of the fungal hyphae throughout the wood, including ramification within the lumina of the tracheids and the wood rays, and (iii) direct penetration through the walls of the wood elements. In the latter process, a noticeable constriction of the hypha occurs as it passes through the cell wall, a condition common also among terrestrial wood-destroying fungi. Similar unsubmerged samples of yellow pine and basswood showed no fungal infestation.

Currently, it is not possible to evaluate completely the role of marine fungi in the deterioration of wood. However, the attack by these fungi upon the physical structure of wood is obvious. In our

laboratory, pure culture studies of many marine genera indicate a definite growth-wise affinity for wood and wood products. Uniclonal attack upon wood, in standing and shaking sea-water aquaria, has been demonstrated repeatedly.

The vigorous fungal infestation of submerged wood prior to borer attack represents a biological phenomenon that investigators of marine wood destruction should not ignore. In northern areas, winter fungal infestation of wood is evident. Hence, in the early spring, when borer activity increases rapidly, the animals have available a wood substrate thoroughly infected by a variety of marine fungi. The interrelationships within this biota are being studied in our laboratory (5, 6).

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5. These studies were supported by contract Nonr 1811(00), Microbiology Branch, Office of Naval Research. This article is contribution No. 188 from the Marine Laboratory, University of Miami.
6. A complete summarization of the fungal infestation at all our test localities is in preparation.

29 July 1957

Coumestrol, a New Estrogen Isolated from Forage Crops

Natural estrogens in plants have assumed considerable importance since the demonstration of their presence in forages and the suggestion of their possible beneficial effects on milk production (1) and meat production (2) and of their probable responsibility for the infertility in sheep grazing on such pastures (3). Included among the forages from which estrogens have previously been isolated are subterranean clover (4) and red clover (5). Other forages which have also been reported to be estrogenic, but from which no estrogens have been isolated to date, include alfalfa, *Medicago sativa*; ladino clover, *Trifolium repens*; strawberry clover, *Trifolium fragiferum*; orchard grass, *Dactylis glomerata*; rye grass, *Lolium perenne*; and blue grass, *Poa pratensis* (6).

All the estrogens previously isolated from forage crops have proved to be isoflavones. These include genistein, biochanin A, and formononetin (7). Genistein and daidzein in the form of their glucosides have also been isolated from soybean oil meal, a generally used feed ingredient. The estrogenic activity of subterranean clover has been attributed to

All technical papers and comments on them are published in this section. Manuscripts should be typed double-spaced and be submitted in duplicate. In length, they should be limited to the equivalent of 1200 words; this includes the space occupied by illustrative or tabular material, references and notes, and the author(s)' name(s) and affiliation(s). Illustrative material should be limited to one table or one figure. All explanatory notes, including acknowledgments and authorization for publication, and literature references are to be numbered consecutively, keyed to the text proper, and placed at the end of the article under the heading "References and Notes." For fuller details see "Suggestions to Contributors" in *Science* 125, 16 (4 Jan. 1957).

Table 1. Uterine response to orally administered estrogen.

Test material and total amount fed per mouse	No. of mice	Av. uterine wt. (mg)
None (control)	5	10
Alcohol extract from 3.5 of dried ladino clover meal	5	41
Crystalline ladino clover estrogen (0.5 mg)	5	34
Crystalline ladino clover estrogen (0.75 mg)	5	61
Genistein (15 mg)	4	28
Diethylstilbestrol (0.2 µg)	5	47
Mentzer's M84* (1.0 mg)	5	101

* 3-(*p*-hydroxyphenyl)-4-*m*-propyl, 7-hydroxycoumarin (9).

the presence of genistein, although it has also been reported that the treatment of clover "chloroplast" with alkali yielded a small amount of a second estrogen with at least 10 times the activity of genistein (8). No information on the chemical nature of this second estrogen was presented, however.

A crystalline compound possessing estrogenic activity has recently been isolated at this laboratory from ladino clover. We have also found estrogenic activity in several alfalfa samples as well as in a sample of fresh strawberry clover; the activity in these samples appears to be attributable to the same estrogen. The compound is the predominant estrogen in strawberry clover, ladino clover and alfalfa, and it appears to be a coumarin derivative rather than an isoflavone. Because of the coumarin structure of the molecule, we propose the name *coumestrol* for the estrogen. The effectiveness of coumestrol as an estrogen has been demonstrated by feeding it to immature female mice and measuring the effect on uterine weight increase. The results of one such assay are presented in Table 1. Genistein and diethylstilbestrol were also included in this study for purposes of comparison. From the data in Table 1 it can readily be seen that coumestrol is considerably more potent than the estrogenic isoflavone, genistein, although it is much less active than diethylstilbestrol.

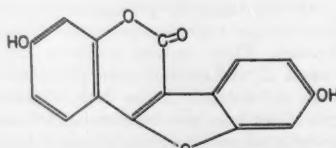


Fig. 1. Proposed structure of coumestrol.

For the bioassay, the estrogen, incorporated in the stock diet of the animals, was fed to 18-day-old immature female mice for a period of 7 days. The mice were killed and the weights of the freshly excised uteri were determined.

The estrogenic compound was isolated by means of solvent extraction of the dried meal, followed by several counter-current distributions, with final recrystallization from methanol.

Coumestrol has a bright blue fluorescence in neutral or acid solution, turning to a greenish yellow in strong alkali. This characteristic greatly facilitated its isolation. It melts with slight decomposition at 385°C (Kofler block). Its ultraviolet absorption spectrum (measured in methanol) shows maxima at 208, 243, and 343 mµ. Alkali fusion of the compound yielded resorcinol and beta-resorcylic acid but no other identifiable phenols or phenolic acids.

Coumestrol has the empirical formula, $C_{18}H_{16}O_5$. Among the derivatives that have been prepared are the diacetate, $C_{18}H_{12}O_7$ (melting point, 234°C) and the dimethyl ether derivative, $C_{17}H_{12}O_5$ (melting point, 198°C), indicating that two free hydroxyl groups are present. There are no methoxyl groups in the compound.

Treatment of coumestrol with dimethyl sulfate under strongly alkaline conditions gave a trimethyl ether-monomethyl ester, $C_{19}H_{18}O_6$ (melting point, 98°C). Mild alkaline hydrolysis of this compound gave the trimethyl ether acid, $C_{18}H_{16}O_6$ (melting point, 178°C). The formation of an acid by this means confirms the presence of a coumarinlike structure in the molecule. Titration of this acid indicated a minimum molecular weight of 331. Decarboxylation of this acid derivative of coumestrol yielded a compound having the empirical formula $C_{17}H_{16}O_4$ (melting point, 82°C). Ozonolysis of this decarboxylated product yielded a number of degradation products, two of which have been identified as 2-hydroxy-4-methoxybenzoic acid and 2,4-dimethoxybenzoic acid. The close agreement between the analytical data obtained and the theoretical data expected from the above derivatives has led us to propose the structure shown in Fig. 1 for coumestrol.

Mentzer *et al.* (9), on purely theoretical grounds, have synthesized a number of coumarin derivatives that showed estrogenic activity. Their most active estrogen was 3-(*p*-hydroxyphenyl)-4-propyl-7-hydroxycoumarin. Except for the alkyl side chain at position 4, a striking similarity exists between our proposed structure for coumestrol and the synthetic coumarin derivative. A recent article (10) reports the isolation of a lactone from *Wedelia calendulacea* with basic structure similar to our proposed

structure, differing however, in number, position and type of substituent groups. Therefore, it would seem that if the proposed structure proves to be correct, coumestrol represents an estrogenic compound not previously reported in the literature.

Note added in proof: We have confirmed the proposed structure of coumestrol and also the estrogenic effectiveness of the synthetic material.

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9 August 1957

Wet Freeze-Drying of Muscle

It was found that acetone, at Dry-Ice temperature, does not denature proteins but still is capable of dissolving water to some extent. It was also found that chlorinated paraffins do not harm contractile proteins at room temperature. This allows one to dehydrate muscle without destroying its molecular structure and contractility.

Fresh frog sartorius muscles or thin strips (1 to 2 mm) of freshly isolated rabbit's psoas were tied to applicator sticks at rest length and immersed in acetone cooled in Dry Ice. The frozen muscle is kept at this low temperature in acetone for a week, after which time the acetone is exchanged with fresh precooled anhydrous acetone in which the muscle is left for a fortnight. We have used 50-ml test tubes as containers and have kept these test tubes in thermos bottles filled with Dry Ice. The acetone slowly dehydrates the frozen muscle. Instead of exchanging the acetone, one can also bind the water extracted from the muscle with granulated $CaCl_2$.

After the water has thus been extracted, the dehydrated muscle is transferred into precooled ethyl chloride and

left in this solvent for a week or so at Dry Ice temperature. The ethyl chloride extracts the acetone. After this extraction has been completed, the muscle preparation is simply taken out of the solvent and is allowed to warm up to room temperature, whereupon the ethyl chloride evaporates. In order to avoid condensation of water, it is advisable to let the preparation warm up in a desiccator or in a small tube closed by a loosely fitting cork, or to allow the ethyl chloride to evaporate in the Deep-Freeze.

The preparation thus obtained is white but has the shape and appearance of the original muscle and is feather-light. On immersion into water, the muscle contracts violently to one-third to one-fifth of its original length. If the water does not penetrate uniformly, the muscle bends towards the more hydrated side, and may double up and break. Contraction can be demonstrated best by cutting up the preparation with a razor blade into thin strips and immersing these in water. The preparation can be kept for several weeks in the desiccator without loss of its contractility. When it is kept in an open vessel, it loses contractility in a few days.

One of us (A. S.-G.) introduced previously the method of glycerination (1). The glycerol-extracted muscle demands adenosine triphosphate and ions for its contraction, these having been washed out. The above "wet freeze-dried" muscle contains these constituents and so demands only the replacement of the extracted water (2).

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9 August 1957

Detection of Manganese-54 in Radioactive Fallout

During the 1956 nuclear test series at the Enewetak Proving Grounds, fallout samples were collected and returned to this laboratory, where they were routinely submitted to gamma spectral analysis. A sample analyzed approximately 300 days after detonation revealed the presence of a gamma emitter with an energy of 0.84 Mev (1). Subsequent to this observation other fallout samples collected from the same operation also exhibited gamma

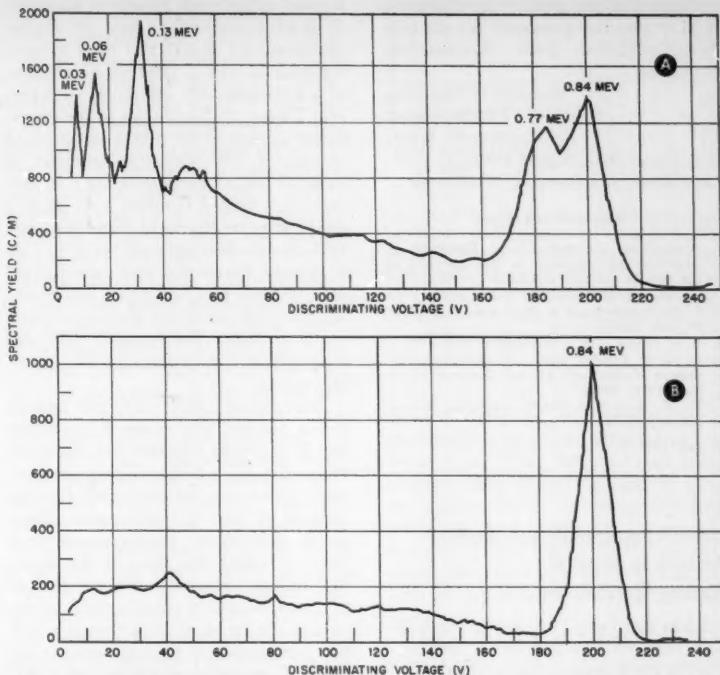


Fig. 1. A, Gamma spectrum of the gross activity in the fallout sample. B, Gamma spectrum of the activity in the isolated sample.

spectral peaks at this energy (2). Since gamma photons with energy of 0.84 Mev are not known to exist in fission products of this age, further study was undertaken to identify the gamma-emitter.

Since Mn⁵⁴ has a relatively long half-life (291 days) (3) and a single gamma energy of 0.84 Mev (4), an analytical scheme was adapted for its isolation. The chemical method consisted of the following steps. Manganese carrier, together with cerium and zirconium hold-back carriers, was added to the dissolved fallout sample, and the whole was oxidized with sodium chlorate. The insoluble manganese dioxide was reduced and solubilized with sodium bisulfite and hydrochloric acid. The solution was scavenged with the aid of basic ferrous acetate (5) to remove interfering nuclides. Manganese was precipitated as the ammonium phosphate and ignited to the pyrophosphate for evaluation of chemical recovery. The resulting precipitate was gamma-counted with a sodium iodide-thallium activated crystal detector and resubmitted to gamma spectral analysis.

Figure 1 shows the gamma spectrum of the activity in the gross sample as well as the gamma spectrum of the activity in the sample isolated by chemical separation. The reliability of the analytical procedure was evident, and the presence of Mn⁵⁴ was confirmed. Its radiations persisted and were more sharply defined after chemical separation, by which the

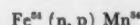
energy peaks characteristic of fission products were completely eliminated. Furthermore, the gamma spectrum of the isolated sample activity was exactly superimposed on the spectrum of an authentic sample of Mn⁵⁴. Aluminum and beryllium absorption curves were taken to establish the identity of the isotope unequivocally. The absorption characteristics were the same as those of the Mn⁵⁴ standard.

Manganese-54 gamma activity (in counts per minute), corrected for chemical recovery, was compared with the gross gamma activity (in counts per minute) of the fallout sample. This radionuclide represented about 40 percent of the total gamma activity. Moreover, calculations indicate that megacurie quantities of this nuclide were produced at the time of detonation.

Stable manganese and iron are possible precursors of Mn⁵⁴ in the presence of high-energy neutrons. The probable nuclear reactions are



and



The appearance of readily detectable quantities of Mn⁵⁴ again emphasizes the importance of considering induced radioactivities in fallout (6). Because of the biological importance of manganese as a trace element, we contemplate an in-

vestigation of the possible incorporation of Mn⁵⁴ into living systems that are subjected to fallout from thermonuclear explosions.

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26 July 1957

Gibberellin-Stimulated Cambial Activity in Stems of Apricot Spur Shoots

Sachs and Lang (1) found that gibberellin increased the number of cell divisions in the subapical region of the shoot of *Hyoscyamus niger*. To our knowledge this is the only report to date of gibberellin stimulating cell division. In this paper, evidence is presented that gibberellin can increase the cell division rate in the cambial zone under certain circumstances. It may be significant that the cambial zone, like the subapical region of a shoot, is normally conditioned for mitotic activity.

In investigations by one of us (J.C.C.) of various macroscopic effects of gibberellin on the growth of the vegetative and reproductive structures of the apricot (2), considerable growth in diameter of stems of spur shoots and of branches 1 year old or older was noted. This growth caused longitudinal splitting of the bark. By contrast, stems of the long shoots formed in the current season

showed no apparent growth in diameter. Scaffold branches of trees of *Prunus armeniaca* cv. Royal had been sprayed on April 10 with a 1000 mg/lit solution of a gibberellin (3) containing 0.05 percent Tween 20. For studies of the microscopic aspects of the gibberellin-induced increase in stem diameter, segments of stems of three typical spurs from control and from treated branches were fixed 5 weeks after treatment in formalin-acetic acid-alcohol. Sections were cut at 40 μ on a freezing microtome and were stained with safranin and fast green. Transverse sections were taken at a distance of 3/16 to 1/4 in. below the terminal bud, and longitudinal ones from segments below that region.

From casual inspection of the sections it was obvious that xylem development had been greatly stimulated by the treatment (Fig. 1), whereas phloem development appeared to be unaffected. In transsections of treated and control spurs, ocular micrometer measurements were made of radial diameters of the secondary xylem, arbitrarily distinguished as the predominantly small-celled xylem outside the series of large vessels which are presumably of primary origin. Because of tangential stretching and radial compression of phloem in treated spurs, the radial thickness of that tissue was not measured. The numbers of cells per radial row were counted in both vertical and horizontal systems of the secondary xylem and also in those systems of all the phloem between the primary phloem fibers and the cambium; the position of the cambium was determined on an arbitrary basis. Since the vascular tissue cylinders are wider in the vicinity of leaf traces, all counts and measurements were made on the side of the stem opposite that in which the three traces to the nearest leaf appeared. For each treated or control spur, one radial measurement and one count of cells in the vertical systems of xylem and phloem were made in each of ten nonserial sections. In the case of numbers of xylem and phloem ray cells in radial sequence, two counts were made in each of ten sections. Ray cell constitution may be a better indication of previous mitotic activity of the cambium, since intrusive growth commonly found in xylem of the vertical system (4) would exaggerate the actual numbers of cells counted in transections, and since ray cell initials in the apricot apparently do not undergo as many divisions, if they undergo any, as the initials of the vertical systems, as evidenced by the greater radial diameters of the ray cells. The mean values for the measurement and cell count data are given in Table 1. Deviations from means of cell counts were inevitably high (the greatest was 31 percent) where the means were less than 10, but dropped to less than 10 percent where the means were greatest.

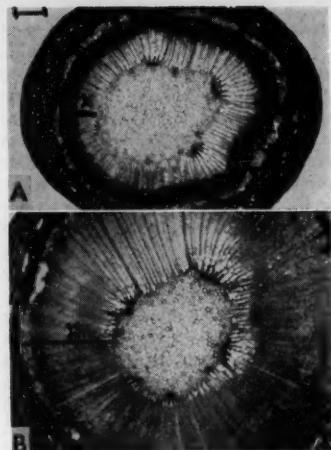


Fig. 1. Transections of stems of spur shoots of apricot showing xylem development in a spur from a control branch (A) and in one from a branch sprayed with gibberellin (B). X, xylem. The scale line at the upper left represents 120 μ.

Larger numbers of cell counts per sample might have changed the means by a point or two but would scarcely have shifted them to different orders of magnitude.

The great discrepancy between treated and control spurs in the radial diameters and numbers of cells along the radius of their xylem cylinders shows indirectly that gibberellin stimulated considerable division in cells of the cambial zone. Particularly significant is the increase in numbers of cells along the xylem rays. This rules out the possibility that increase in diameter of the secondary xylem resulted largely or exclusively from greater elongation and intrusive growth of cells of the vertical system. Indeed, the similarity of ratios of mean numbers of cells of the vertical system to corresponding means for the rays (1.7, 1.2, and 1.5 for the three controls; 1.6, 1.6, and 1.5 for the three treated spurs) suggests that there may have been no essential difference in intrusive growth between treated and control samples. The data from cell counts in the phloem show that gibberellin had little or no effect on stimulating addition of new cells to that tissue. It would be tempting to consider that gibberellin might have influenced differentiation indirectly by affecting the polarity of cambial divisions. However, the emphasis on initiation of xylem rather than phloem elements could be merely an exaggeration of the particular phase of the natural growth pattern affecting all spurs at the time of gibberellin treatment (5). Perhaps treatment at a different date would stimulate phloem development commensurate with xylem development.

Table 1. Xylem and phloem development in stems of spur shoots from apricot branches sprayed with gibberellin and from control branches.

Shoot	Radial diam. (μ)	Secondary xylem		Phloem	
		Controls		Treated shoots	
		Mean No. of cells along radial diam.	Mean No. of cells along radial diam.	Vertical system	Horizontal system
A	144	16.4	9.9	20.1	6.4
B	133	13.2	10.6	19.2	6.0
C	164	18.9	12.8	18.1	7.3

The occurrence of considerable gibberellin-stimulated cell division in the cambial zone in the current season's growth of apricot spur shoots but not in that of the long shoots would appear to be connected with differences in the growth phases of the two types of shoot. At the time of treatment the terminal buds of the long shoots were still active, whereas those of the spurs had already entered their rest phase. Application of gibberellin stimulated longitudinal growth of long shoots and in no way interfered with their lateral bud and shoot development. However, it not only failed to break the rest of buds on spur shoots but actually retarded bud development, as is indicated by the smaller size of buds on treated spurs than on those of controls.

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29 July 1957

Tidal Overmixing in Estuaries

The eddies and currents which move salt water from the ocean into coastal estuaries and then mix the salt water with the outflowing fresh river water are important in determining the concentration pattern and movement of all suspended and dissolved materials in the estuary. Concentrations of salt, pollutants, oxygen, plankton, nutrients, and silt are in part controlled by the pattern of motion.

Salt water moves upstream against the river flow by processes ranging from the advection of a pure salt-water wedge flowing in on the bottom of deep estuaries to eddy diffusion associated with tidal currents in shallow water (1). The purpose of this report (2) is to discuss one of the processes of eddy diffusion that is due to tidal currents in the Coos Bay and river estuary on the Oregon coast; the discussion may be applicable to similar estuaries in other regions.

The Coos Estuary would be classed (1) as a positive, vertically homogeneous estuary with the principal movement of salt water upstream being caused by tidal eddy diffusion. The salt content is nearly constant with depth everywhere in the estuary, and it increases linearly from the fresh river water at the head of the estuary to full sea water at the

mouth. The estuary is cut through low, coastal mountains and might be called a mountainous coast estuary. Although much of its area is composed of shallow tide flats, its average width is less than 1 mile. A narrow channel with mean depths of 7 to 10 m extends inland for 15 miles. The tides are the characteristic mixed tides of the West Coast, with a mean range of 1.6 m and a maximum range of 3.1 m. At times, the surface currents exceed 6 knots.

Higher high water is usually followed by lower low water, lower high water, and higher low water, in that order. From observations of salinity, which are discussed later, it can be inferred that the tidal excursion is greater at the surface than along the bottom, where bottom friction tends to retard the tidal currents. Right after low water, the whole estuary is nearly vertically homogeneous, having the same salt content from the surface to the bottom in any given position. During flood tide, the surface water moves upstream more rapidly than the bottom water. This causes an unstable salinity and density inversion, with more salt, more dense water on the surface than on the bottom. The heavier water sinks and the lighter water rises, causing mixing throughout the water column all the way from the surface to the bottom. This instability should appear during flood and high water.

During ebb, the surface water again out-distances the bottom water, but stability which may be observed during ebb and at low water is set up. Ebb currents are combined with river flow to give maximum velocities. These in turn bring about some turbulent vertical mixing during flow over the relatively shallow bottom. This tends to inhibit the formation of strong vertical stability.

Seven hundred and eighty-nine sets of surface and bottom salinity and temperature observations were examined statistically (3156 observations in all) in

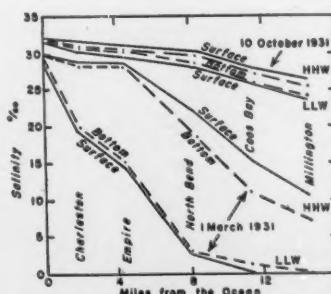


Fig. 1. The observed surface and bottom salinity distribution in the Coos Estuary on 1 March and 10 October 1931. Data for higher high water (HHW) and lower low water (LLW) are given. The place names are the locations where observations were made.

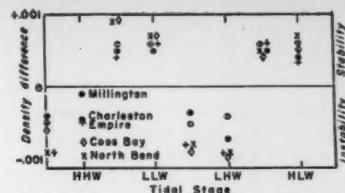


Fig. 2. Median density differences between the surface and the bottom water for five different stations at eight different tidal stages. Mean depths at station locations were Charleston, 4.5 m; Empire, 4.5 m; North Bend, 8.2 m; Coos Bay, 7.5 m; and Millington, 3.9 m.

order to determine how often, and to what degree, the above pattern was followed in the Coos Estuary. Data were available from five stations on the estuary. Figure 1 shows typical salinity data for higher high water and lower low water for 2 days during 1931. Note that salinity inversions were present at all stations at higher high water during both days.

The available data had been taken at bi-weekly intervals of time over a 3-year period. Each station was visited from three to five times on any given day of sampling. All observations were made at the time of a high or a low water at the location of the station or at a time half way between a high and low water or a low and high water.

All temperature and salinity data were next converted to density, ρ . In this case, the relative density between the surface and bottom was desired, so that no correction was made for pressure. The density of the surface water was then subtracted from the density of the bottom sample to give a $\Delta\rho$ for each pair of observations. Positive values of $\Delta\rho$ indicate stability, while negative values indicate instability. The data for each station were then grouped into eight groups, according to the stage of the tide at the time the observations were made (higher high water, between higher high water and lower low water, lower low water, and so forth). The algebraic median values of each of the 40 groups of data were determined and plotted (Fig. 2). According to the above hypothesis, $\Delta\rho$ should be negative, indicating instability during both floods and high waters; $\Delta\rho$ should be positive during ebbs and low waters, indicating stability. The median values plotted on Fig. 2 have the expected sign in all cases. Of the 789 individual density differences, 87 percent have the expected sign, 3 percent were zero, and only 10 percent have the opposite sign from that expected.

It is clear that the process described, which we will call "tidal overmixing," must be of importance in the Coos Estuary and similar estuaries. The process of

the tidal flow setting up an unstable condition, which is followed by mixing of the whole water column during flood and high water, aids in the movement of salt against the mean flow of the river passing through the estuary. This occurs at all stations from the mouth to the head at all times of the year. The data were insufficient to show whether the density inversions were more likely to occur at any particular stage of the river.

In addition to assisting in the maintenance of the salt balance in the estuary, the tidal overmixing causes ventilation of the bottom waters at frequent intervals. Oxygen, nutrients, plankton, pollutants, and any other suspended or dissolved materials are mixed throughout the whole water column on almost every tidal cycle throughout the year.

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* Deceased.

26 August 1957

X-ray Induced Chromosome Aberrations in Normal Diploid Human Tissue Cultures

In recent years, and particularly in recent months, the estimation of radiation hazards to human populations has become very important. While there is an enormous body of data on other organisms, there are few data on human beings. Without some indication of the sensitivity of humans in relation to the better known organisms, it is difficult to make quantitative estimates of radiation hazards to humans.

The recent development of simple, reliable methods of tissue culture, especially those developed for virus research (1), make it easy to grow mammalian cells for genetic and cytological studies. The discovery by Hsu and Pomerat (2) of an improved method of preparation of tissue-culture cells offered the possibility of making cytological studies of radiation damage to human chromosomes by direct examination for aberrations, as is done with the classical plant materials.

Such a study must, of course, be made on diploid cells derived from normal tissues. Many existing human tissue-culture cell lines derived from normal tissue have been examined cytologically by myself and other workers; but,

Table 1. Aberrations in cultured epithelioid diploid human kidney cells after treatment with x-rays.

Time (hr)	Dose (r)	Cells scored (No.)	Chromatid deletions (No.)	Isochromatid deletions (No.)	Chromatid exchanges (No.)	Total breaks (No.)	Breaks per 100 cells (No.)
42	Control	150	1	0	0	1	0.7
42	25 r	147	2	6	1	10	6.8
42	50 r	74	3	11	1	16	21.6
49	Control	150	1	1	0	2	1.3
49	25 r	150	2	6	0	8	5.3
49	50 r	133	2	13	2	19	14.3
72	Control	67	0	0	0	0	0.0
72	25 r	60	0	2	0	2	3.3
72	50 r	43	0	2	0	2	4.7

unfortunately, they have all turned out to be polyploid, apparently basically tetraploid, with wide aneuploid variations. Since it was known from work on monkey kidney chromosomes in our laboratory that a newly set line did not become basically polyploid until after at least the sixth passage, a new line was set from normal human kidney. The newly cultured tissue was found to have 46 chromosomes and, from the first to the fourth passage, to contain an average of only 8 percent of polyploid cells.

For the present studies (3), epithelioid cells for the second to the fourth serial cultures were used. The cultures were made from a normal kidney which was removed from a 1-year-old female patient at the Johns Hopkins Hospital (4). The kidney cultures were prepared by a modified Younger (1) technique and grown in a modified Chang's medium (5). The experimental cultures were made on cover slips in Leighton tubes. When a good sheet of cells had grown on the cover slips (3 to 6 days), the tubes were used for irradiations.

The x-irradiations (6) were performed with a G.E. Maxitron therapy machine. It was operated at 250 kv (peak) and 15

ma with filtration through 1 mm of aluminum and 1 mm of copper. The half-value layer was 2 mm of copper. Two doses, 25 and 50 r, were used.

The nutrient solution was drained from the tubes before they were treated and was replaced with fresh solution afterward. Control tubes were handled in exactly the same manner in this and all other respects, excepting actual irradiation. About 15 hours before the cultures were to be fixed, colchicine was added to a final concentration of $10^{-7} M$. The cells were first incubated for 20 minutes in a 20 percent BSS solution and then fixed in Darlington and LaCour's 2BD and stained by the Feulgen method.

Preliminary experiments had shown that the most favorable time interval between irradiation and fixation was 40 to 72 hours. Aberration counts were made on material fixed 42, 49, and 72 hours after treatment. Control material, fixed at each interval, was also examined. Only diploid cells were scored. All of the expected types of aberration were found in the irradiated material. A normal figure from control material is shown in Fig. 1a, and a figure containing a chromatid deletion is shown as Fig. 1b.

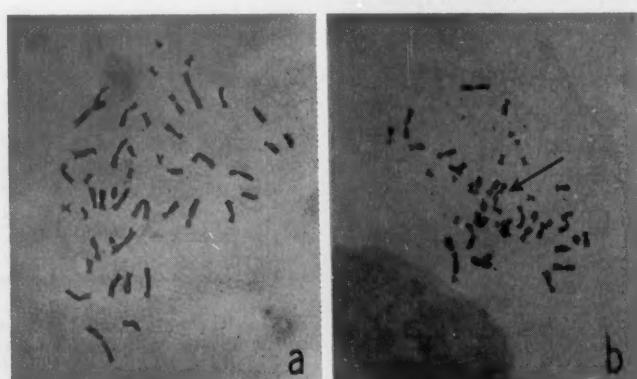


Fig. 1. Colchicine-treated metaphase figures from tissue-cultured epithelioid diploid human kidney cells. (a) Normal figure from control material. (b) A figure from the 42-hour, 25-roentgen series, showing a chromatid deletion (arrow).

The results of the experiment are shown in Table 1. All of the samples smaller than 150 cells include all scorable cells in the sample. The 72-hour sample is included here in spite of its small size, because it shows a significant drop in the frequency of aberrations over the 42- and 49-hour samples, probably because the cells scored in the 72-hour sample were in early interphase at the time of irradiation. The differences between the irradiated samples and the controls for the 42- and the 49-hour samples are significant at the 1-percent level. The differences between the 42- and the 49-hour samples are not significant.

It is, of course, very obvious that before any definite conclusions can be drawn about the sensitivity of human tissues to radiation, the present preliminary work must be repeated on the same and other tissues. However, in the absence of other data and in view of the importance of the subject, it seems proper to point out that the present work indicates that human tissues may be much more sensitive to ionizing radiation than was previously suspected. If one combines the 42- and 49-hour data, the control rate is one break per 100 cells. The slope of the dosage versus breakage curve is about 0.3 break per 100 cells per roentgen. The doubling dose, for the types of aberrations scored and for this material, is thus about 3.3 roentgens. This is roughly one third of the maximum permissible dose recently recommended by the National Academy of Sciences' report on the Biological Hazards of Atomic Radiation. It should be pointed out that the National Academy's recommendation was based on estimates of gene mutations, which may not be as easily induced by x-rays as chromosome aberrations.

Work is in progress in this laboratory to determine induced gene mutation frequencies in normal diploid human cells *in vitro*. Although there is no proof that cells in tissue culture respond to radiation in the same manner as rapidly reproducing tissues in the body, there is no evidence that they do not. It is clear that if the rates of this and other types of radiation damage to human cells are found to be correspondingly high in further experiments, a sharp revision will have to be made in our estimates of "safe" doses of radiation, if, indeed, any dose can be called "safe" from a genetic point of view.

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2 October 1957

Pressure-Sensitive Telemetering Capsule for Study of Gastrointestinal Motility

Existing methods for the accurate measurement and recording of pressure changes within the human gastrointestinal tract require the passage of tubes through the mouth, nose, or anus, or through an artificial opening provided by gastrostomy, ileostomy, or colostomy. The principal objections to these methods are (i) that the distal small intestine and proximal colon are relatively inaccessible for study and (ii) that normal gastrointestinal motility may be altered by reflex changes induced either by the physical presence of the tube or by the discomfort experienced by the patient.

An instrument has been devised which will permit the recording of gastrointestinal motility under more physiologic conditions. This instrument is sensitive to intraluminal pressures and records these pressures without connecting wires or tubes. It consists of a rigid, plastic, cylindrical capsule 3.0 cm in length and 1.0 cm in diameter (Fig. 1). The capsule contains a transistor radio transmitter powered by a battery having a "life" of 15 hours. A screw-on cap at one end of the capsule permits replacement of the battery. The opposite end of the capsule is a flexible rubber membrane which covers

a pressure transducer. Pressure applied to the transducer modulates the frequency of the oscillations generated by the transmitter. These signals are accepted by the antenna of a frequency-modulation receiver. The receiver demodulates the signals, and the pressure variations are displayed on an oscilloscope and recorded photographically. The capsule detects pressures ranging from 0 to approximately 50 cm of water and responds to frequencies between 0 and 100 cy/sec.

This pressure-sensitive device has been used to record pressures within the gastrointestinal tract in normal human subjects. Prior to ingestion of the capsule, the entire detecting and recording apparatus is calibrated in an external system. The capsule is placed in a bottle, which is rendered air-tight by a two-hole stopper. One opening admits a water manometer, and the other permits injection of increments of air. The pressures developed within the bottle are recorded in the usual fashion by means of the frequency-modulation receiver and the antenna which is placed near the bottle. A given excursion of the photographic record corresponds to the pressure change indicated by the water manometer. Such calibration permits accurate derivation of relative intraluminal pressures from the final record.

The recording of gastrointestinal pressures in man is accomplished with the subject in any comfortable position and with the antenna secured loosely to the abdomen. Respirations are recorded simultaneously by a pneumograph attached to a strain-gage manometer. Both the intraluminal pressures and the respiratory excursions are recorded by a multi-channel photographic recorder and displayed on an oscilloscope. The capsule may be swallowed without difficulty, and it passes through the gastrointestinal

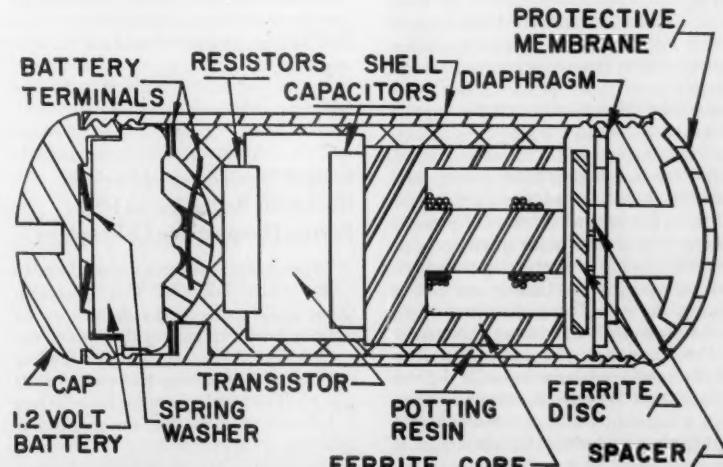


Fig. 1. Cross-section of the pressure-sensitive radio transmitter.

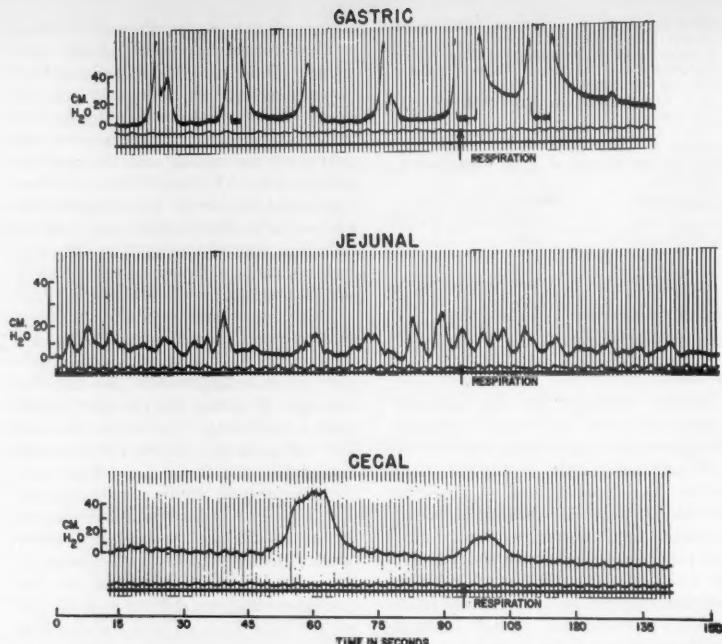


Fig. 2. Records of intraluminal pressure from three different portions of the gastrointestinal tract.

tract without causing discomfort. It is radioopaque and can be followed fluoroscopically. The radio transmitter sends signals constantly until the battery charge is exhausted. During a 15 to 20 hour period, therefore, intraluminal pressure changes are continuously displayed on the monitoring oscilloscope whenever the antenna is near the subject. Permanent records may also be made continuously or at intervals.

Records have been obtained of gastric and small intestinal intraluminal pressures in four subjects, and in two of them colonic records have also been obtained (Fig. 2). Preliminary studies in these four subjects indicate that the gastric and small intestinal phasic pressure changes correspond in frequency and general appearance to those phasic patterns recorded by other methods. If the capsule is swallowed when the subject is fasting, very little activity of the stomach is noted. After the ingestion of food, gastric pressure waves occur at an approximate rate of three per minute. Records of pressure fluctuations in the small intestine show periods of activity alternating with periods of quiescence. During the active phases, the waves occur at a rate which varies between 7 and 14 per minute.

Precise analysis of records of activity in the small and large intestine will be complicated because the detecting capsule is constantly moving "downstream" rather than recording the activity of a single segment. If it is desired, the capsule may be anchored in one locus for

periods of time by means of a very thin thread which passes through the mouth and is anchored externally.

The pressure-sensitive radio transmitting capsule appears to possess considerable potential for the study of gastric, small intestinal, and proximal colonic motility since it does not alter normal physiological processes.

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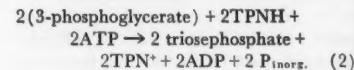
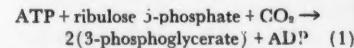
Medical Service, Veterans Administration Hospital, New York, Department of Medicine, Cornell University Medical College, New York, and Medical Electronics Center, Rockefeller Institute, New York

15 July 1957

Lack of Dependence of Pyridine Nucleotide Reduction on High-Energy Phosphates in Chloroplasts

Experimental evidence accumulated in recent years indicates that photosynthetic CO_2 fixation and reduction to the carbohydrate level mainly depends on the availability of reduced pyridine nucleotide and of high-energy phosphate bonds ($\sim \text{P}$). The requirement for both factors is fulfilled by a mechanism specifically localized in the chloroplasts. This mechanism comprises (i) the splitting of water into an oxidizing and a reducing agent

by means of light energy, (ii) the conversion of some of the chemical potential energy thus produced into $\sim \text{P}$ of adenosine triphosphate (ATP) during the step-wise transfer of electrons from the primary reducing agent to the oxidizing agent, and (iii) the use of the remaining part of the chemical potential energy for the reduction of a pyridine nucleotide, probably triphosphopyridine nucleotide (TPN). The presumed utilization of reduced triphosphopyridine nucleotide (TPNH) and ATP in photosynthesis is illustrated by the following equations:



The question then arises whether TPN is on the pathway of electron transfer from the primary acceptor of reducing power to the oxidizing agent produced by the photolysis of water, thus participating in the electron-transferring, phosphorylating system, as suggested by Bassham and Calvin, (1), or whether it is outside the phosphorylative chain, and secondarily reduced by some element of the same, as suggested by Kandler (2), Arnon (3), and Wessels (4).

The tentative schemes proposed by Kandler and by Arnon are based on the fact that ATP synthesis by illuminated chloroplasts is stimulated by flavin mononucleotide, vitamin K, and ascorbate, and not by pyridine nucleotides. In these schemes, either vitamin K or flavin mononucleotide would be directly reduced by the chlorophyll-light system through a one-quantum process. Pyridine nucleotide reduction by a part of the reduced flavin mononucleotide or reduced vitamin K that is formed would then follow, the energy for such an endergonic reaction being supplied by ATP generated during the oxidation of the residual reduced flavin mononucleotide or reduced vitamin K.

It seemed to us that an indication about the position of TPN in the photosynthetic electron-transfer mechanism could be obtained by testing the dependence of TPN reduction by illuminated chloroplasts on the availability of high-energy phosphate in the system. In fact, utilization of $\sim \text{P}$ in a coupled reaction appears to be by far the most probable mechanism by which electrons could be moved from a more positive to a more negative system (as from flavin mononucleotide or vitamin K, with E_h near -0.0 v. to TPN, with E_h near -0.32 v.). If, therefore, reduction of TPN by illuminated chloroplasts could proceed unimpaired under conditions in which high-energy phosphate production was suppressed, or immediately deviated to

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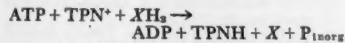
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Table 1. Lack of dependence on ATP of the reduction of TPN by illuminated chloroplasts. The complete system contained, in addition to chloroplasts, mannitol (0.42M); Tris buffer (0.02M) at pH 7.4; MgSO₄ (0.004M); KCl (0.03M); EDTA (0.01M); TPN (200 µg); GS-SG (600 µg); TPNH-glutathione reductase from 20 mg of acetone powder of pea leaves. 2,4-Dinitrophenol (DNP), or hexokinase and glucose, was added, when indicated, 5 minutes before the addition of TPN and GS-SG. The final volume was 1.0 ml. The preparation was incubated at 12°C in a vacuum, under illumination by a 200-w lamp 15 cm away.

Conditions	Reduced glutathione formed (µmoles/mg of chlorophyll per 10 min)
Complete system	0.00
Dark	
Light	1.11
Complete system plus DNP (10 ⁻⁵ M)	0.54
Complete system plus hexokinase (30,000 K.M. units) and glucose (0.025M)	1.26
Complete system minus TPN	0.06
Complete system minus GS-SG	0.00
Complete system plus ATP (10 ⁻⁴ M)	1.00

some highly efficient acceptor system, competing with the hypothetical reaction



(X representing the unknown primary acceptor in photosynthesis), this should represent reasonably good, though indirect, evidence in favor of the reduction of the coenzyme by an electron donor with an E_o near -0.3 v or more negative—that is, by either the excited chlorophyll system or by some primary electron acceptor as, possibly, lipoic acid (1). In this case, there would be no difficulty in assuming that the role of TPN in photosynthesis is not only that of reducing 3-phosphoglycerate, but also that of an intermediary electron carrier in the phosphorylative chain, in analogy with what is known of the mitochondrial oxidative-phosphorylative system.

In the present experiments, TPN reduction by illuminated whole chloroplasts (5-7) was detected by using the oxidized glutathione (GS-SG)-glutathione reductase trapping system (Hendley and Conn, 7) the amount of glutathione reduced in a given time being taken as measure of the TPN-reducing activity of the chloroplast suspensions. The relation between high-energy phos-

phate availability and TPN reduction has been studied through different approaches, namely, (i) under conditions in which photosynthetic phosphorylation was completely inhibited by the presence of 10⁻⁵M 2,4-dinitrophenol (DNP), a compound which, as shown by Arnon *et al.* (3) (the finding was confirmed in our laboratory), almost completely suppresses phosphate uptake by illuminated chloroplasts, while it inhibits photolysis of water to the extent of only 50 percent; (ii) in the presence of a very efficient high-energy phosphate trapping system, the hexokinase-glucose system; (iii) under opposite conditions—that is, in the presence of an ample supply of ~P, provided as ATP.

The results shown in Table 1 appear to be definitely unfavorable to the hypothesis of a participation of high-energy phosphate in TPN reduction by illuminated chloroplasts. It may be seen that, in the presence of 10⁻⁵M DNP, GS-SG reduction is inhibited only by the extent of about 50 percent (which corresponds to photolysis inhibition), while a much more severe inhibition should be expected if the process were ATP-dependent, for phosphorylation is almost completely suppressed by 2,4-dinitrophenol at this concentration. Moreover, the presence of the hexokinase-glucose system, which should severely compete with an ATP-dependent, TPN-reducing mechanism for ~P, and thus markedly decrease GS-SG reduction, seems to stimulate the latter. Finally, no increase in GS-SG reduction is caused by the addition of relatively large amounts of ATP to the system.

These results, in their simplest interpretation, support the hypothesis of a direct, ATP-independent reduction of TPN by the primary reducing agent of photosynthesis, a conclusion which is consistent with the hypothesis of an important role for TPN in photosynthetic phosphorylation, as suggested by the recent finding of a flavin activated TPNH-cytochrome c reductase in chloroplasts, and of a marked stimulating effect of TPN and cytochrome c (when supplied together) on the phosphorylating activity of illuminated chloroplasts (6).

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21 June 1957

Human Liver Enzymes of Glucose-6-Phosphate Utilization

A great wealth of biochemical data has been accumulated from experiments performed with laboratory animals. However, the applicability of the results to human metabolism is always a problem because of species differences (1). We have been engaged during the past 4 years in the study of the hepatic enzymes which govern glucose-6-phosphate utilization under physiological and pathological conditions. The behavior of the four enzymes which are involved in the immediate utilization of glucose-6-phosphate (glucose-6-phosphatase, phosphoglucomutase, glucose-6-phosphate dehydrogenase) has been elucidated in neoplastic, regenerating, embryonic, and newborn liver (2) and in the liver of fed and fasted normal rats (3). The hormonal control of these enzymes has also been investigated (4-6). A considerable amount of information has been collected from these studies, and the question naturally arises how far can the data obtained in rat liver be applied to human liver. There are a few studies on glucose-6-phosphatase in human liver (7, 8). However, a systematic investigation of all four enzymes which govern glucose-6-phosphate utilization has not yet been reported for adult human liver. This report (9) presents the results of a study of these four hepatic enzymes in human liver and compares their activities with those of the rat liver enzymes.

The specimens of human liver were obtained by biopsy at abdominal operations from patients with clinical diagnosis of cholecystitis and cholelithiasis. Hematoxilin and eosin slides were made of each specimen. Only those biopsy results which showed normal liver structure on histological examination were included in the present series (10).

Rat livers were obtained from male adult animals of weight 200 g. The human tissue biopsy samples were put on ice immediately, and 10-percent homogenates were prepared in isotonic KCl (2) in 1/2 to 2 hours after the tissue was removed. The supernatant fluid was obtained by centrifuging the homogenate for 30 minutes at 0°C at 100,000 g in a refrigerated Spinco model L centrifuge. Nitrogen determinations were done by the micro-Kjeldahl method. Glucose-6-

Table 1. Amount of glucose-6-phosphate metabolized *in vitro* under optimal pH and substrate conditions by human and rat liver enzymes. The means and standard deviations of six or more specimens are given. The results given in parentheses are percentages; the values for phosphohexoseisomerase were taken arbitrarily as 100 percent.

Enzyme	Activity per gram (wet weight) (μmole/hr)		Activity per milligram of nitrogen (μmole/hr)	
	Rat	Human	Rat	Human
Phosphohexoseisomerase	10730 ± 1733 (100)	15630 ± 5241 (100)	715 ± 95 (100)	1122 ± 326 (100)
Phosphoglucomutase	6932 ± 803 (65)	10149 ± 5046 (65)	463 ± 51 (65)	711 ± 312 (64)
Glucose-6-phosphatase	463 ± 49 (4.3)	255 ± 118 (1.6)	14.4 ± 1.5 (2.0)	8.4 ± 3.8 (0.8)
Glucose-6-phosphate dehydrogenase	65 ± 24 (0.6)	90 ± 24 (0.6)	2.3 ± 0.9 (0.3)	5.2 ± 1.4 (0.5)
<i>Ratios</i>				
Phosphohexoseisomerase/ Phosphoglucomutase	1.55	1.54	1.55	1.55
Glucose-6-phosphatase/ Glucose-6-phosphate dehydrogenase	7.1	2.8	6.3	1.6

phosphatase was assayed in the homogenate; phosphoglucomutase, phosphohexoseisomerase, and glucose-6-phosphate dehydrogenase were assayed in the supernatant fluid. Glucose-6-phosphatase was measured in micrograms of phosphorus liberated per 15 minutes per gram (wet weight) of tissue at 37°C (2, 7). Phosphohexoseisomerase activity was measured according to the method of Bruns and Hinsberg as modified by Glock and McLean (11). One unit is the quantity of enzyme which produces 1 μmole of fructose-6-phosphate per minute per gram (wet weight) of tissue at 37°C. Phosphoglucomutase activity was measured by determining the decrease in acid-labile phosphorus after a 3-minute hydrolysis in 5N sulfuric acid at 100°C (12). One unit is the quantity of enzyme which catalyzes the disappearance of 1 mg acid-labile phosphorus per 10 minutes per gram (wet weight) of tissue at 37°C. Glucose-6-phosphate dehydrogenase activity was determined by the method of Glock and McLean (6). One unit is the amount of enzyme which reduces 0.01 μmole of triphosphopyridine nucleotide per minute per gram (wet weight) of tissue at 37°C. The enzymatic activities are expressed per gram (wet weight) and per milligram of nitrogen. Proportionality to time and amount of enzyme at optimal substrate concentration was established for all four enzymes before the experiments described in this paper were started.

The nitrogen content of the rat liver was as follows: homogenate, 31.9 mg/g (wet weight); supernatant, 15.0 mg/g. The nitrogen content of the human

liver was very similar: homogenate, 29.6 mg/g; supernatant, 14.1 mg/g.

A comparison of the enzymatic activities in rat and human liver is presented in Table 1. All enzymatic activities are compared at optimal pH and substrate conditions at 37°C. Under these circumstances in the rat liver, phosphohexoseisomerase and phosphoglucomutase are the most powerful enzymes, while the rate of glucose-6-phosphatase is quite low, and the rate of glucose-6-phosphate dehydrogenase is the slowest on both a wet weight and a nitrogen basis. Glucose-6-phosphate dehydrogenase activity was demonstrated only in about 30 percent of the samples examined. However, 6-phosphogluconic dehydrogenase activity was always present. It is possible that the method used for measuring glucose-6-phosphate dehydrogenase activity is not sensitive enough to detect activities as low as 0.4 μmoles of substrate reacting per minute per milligram of nitrogen.

The glucose-6-phosphate utilizing enzymes of the human liver show a remarkable parallelism with the rat enzymes. The absolute values of phosphoglucomutase and glucose-6-phosphate dehydrogenase are higher in the human liver. On the other hand, the glucose-6-phosphatase activity is lower. An attempt has been made to compare the ratio of phosphohexoseisomerase/phosphoglucomutase and glucose-6-phosphatase/glucose-6-phosphate dehydrogenase in rat and human liver. The previous ratio was chosen to compare the storing (glycogenic) and energy-yielding (glycolytic) pathways, the latter ratio to compare the activi-

ties of the two enzymes which channel glucose-6-phosphate into release (hydrolysis) or into nucleic acid metabolism (hexose monophosphate shunt). The phosphohexoseisomerase/phosphoglucomutase ratio is 1.55 in both rat and human liver on a nitrogen basis. However, the glucose-6-phosphatase/glucose-6-phosphate dehydrogenase ratio is 6.3 in the rat liver and only 1.6 in the human liver on a nitrogen basis. This lower ratio is due to both lower glucose-6-phosphatase and to higher glucose-6-phosphate dehydrogenase values of the human liver. It is of importance to note that the glucose-6-phosphatase/glucose-6-phosphate dehydrogenase ratio of rat liver on wet weight basis (7.1) agrees well with the ratio (6.7) which may be calculated from the data of Perske *et al.* (13) on normal rat liver.

The comparison of data for human and rat liver shows encouraging similarities in the absolute values. However, the presence of specific biochemical species characteristics is clearly demonstrated when the results are expressed in ratios. The results offer hope for further comparison of human- and rat-liver metabolism. An attempt is now being made to characterize human hepatic physiology and pathology by the study of the four strategic enzymes on which the metabolic fate of glucose-6-phosphate depends.

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Book Reviews

The Beginnings of Chinese Civilization. Three Lectures Illustrated with Finds at Anyang. Li Chi. Foreword by M. Rogers. University of Washington Press, Seattle, 1957. xvii + 123 pp. Plates. \$6.50.

In the '30's of the present century, systematic excavations at the capital of the Shang Kingdom (circa 15th to 11th centuries B.C.) revealed a wealth of information about the beginnings of Chinese culture, parallel with the greatest discoveries at Troy, Knossos, or elsewhere. Li Chi, who is justly compared by the editor of this little book with Heinrich Schliemann, was in charge of these excavations in the North China plain for a number of years and today is universally honored as one of the greatest living Chinese archeologists. No reader interested in such a subject will regret the cost of this book, illustrated as it is with so many plates, some quite new.

The first chapter gives a general authoritative account of the paleolithic and neolithic times in China, showing how the organization of the first state power was marked by decisive new developments—an outstanding bronze metallurgy, the formation of the first system of Chinese script (the oracle-bone characters), the introduction of chariots, an advanced stone-carving art, *terre pisé* buildings, elaborate royal burials, and new kinds of ceramics, involving kaolin and glaze. In the second chapter Li describes the greatly increased use of animals, both wild and domestic, including the buffalo, which distinguished the Shang people from their neolithic predecessors. Traces of similarities with western Asia now appear, such as phallic jar covers, and a "hero-and-beast" motif which recalls the Gilgamesh Epic of the Fertile Crescent; Amerindian totem poles are suggested by certain Shang carvings.

Opinions may differ about the convincingness of these parallels, but they are more acceptable than the suggestion made earlier of a connection between certain ancient Chinese "hairy man" legends and the descendants of the Old Man of the Chou-Kou-Tien Upper Cave—a paleolithic person. Li also seems to smile upon the identification of certain faces on Shang bronzes as being those

of Negroes or Negritos; I am open to conviction but not yet convinced. More immediate agreement is won by the finding that the rectangular bronzes of the Shang derive from wooden forerunners, while the round ones derive from pottery predecessors.

Perhaps Li's most important disclosure in this book is that concerning the analyses of Shang bronzes carried out by the chemists of Academia Sinica. Differences between contemporary objects thus demonstrate that the Shang people knew the differences in properties brought about by varying the percentages of copper and tin (and lead) in their bronze. The knowledge expressed in a famous text of the third century B.C. is thus clearly exhibited 1000 years earlier.

The book ends with a discussion of the typology of bronze knives, vessels, and dagger-axes. The only criticism which could be voiced concerns the publisher and editor rather than the author; the Chinese characters inserted in the text are microscopically small, and their insertion is not systematic. It was a pity to "spoil the ship for a ha'pennyworth of tar."

JOSEPH NEEDHAM
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Nonparametric Methods in Statistics. D. A. S. Fraser. Wiley, New York; Chapman & Hall, London, 1957. 299 pp. Illus. \$8.50.

One area of statistical research that has received increased attention in recent years is the area of nonparametric statistics. Historically, the development of statistical inference was concentrated in the area of parametric statistics—in techniques which made many assumptions about the universe from which the observations were drawn. These assumptions are generally in the form of the parameters or population values that characterize the population. The most famous of these populations has been, of course, the normal population.

In the development of nonparametric statistics, fewer assumptions are made about the universe from which the sample observations are drawn. In fact, then, these nonparametric methods deal with

statistical inference on a more general level than do parametric methods.

In this volume the author sets himself the task of collecting the developments in the field of nonparametric methods that have taken place in recent years. His approach is not merely to collect and present a set of techniques. His approach has been a more general one—"to restate the standard problems in quite general terms and then look for adequate statistical procedures." Among the standard problems he discusses are single-sample problems (the problems of fit, location, and symmetry), randomness problems, and randomized blocks and other experimental designs.

The first two chapters offer an excellent review of the general techniques of estimation and hypothesis testing, which forms the basis for the subsequent discussion of nonparametric methods. The volume constitutes a welcome addition to the statistic library and will reward anyone paying it the careful attention it deserves.

IRVING ROSHWALB
Audits and Surveys Company, Inc.

Biochemical Disorders in Human Disease. R. H. S. Thompson and E. J. King, Eds. Academic Press, New York, 1957. 843 pp. \$12.60.

This book consists of a series of essays on 20 different types of diseases, written by 31 authors of whom about one-third are from American, and two-thirds from British, laboratories. The editors are both chemical pathologists.

The orientation of the authors is for the most part that of pathologists; they have, generally, written about the diseases in question in a traditional manner with, however, the realization that biochemistry is of vital and growing importance and must be brought into the discussion. It is 50 years since what was presumably the first book entitled *Chemical Pathology* was published. In spite of the growing emphasis on biochemistry, the present volume cannot be said to be biochemically oriented to a high degree. This is illustrated by the fact that among the topics which are, in most cases, omitted in the index and which do not enter into any serious discussions in the text are adaptive enzymes, biochemical genetics, coenzyme A, cytochromes, disease susceptibility, flavoprotein enzymes, gene mutations, the genetotrophic concept, pantothenic acid, pyridoxin, pyrimidines, riboflavin, templates, and viruses. As the editors state in the preface, no separate chapters deal with diseases of the skin, infectious diseases, gerontology, or cancer.

In spite of limitations stated or implied, this is a valuable volume and con-

tains, in an orderly form from the pathologist's point of view, a review of the recent findings with respect to the diseases discussed. Some of the material is excellent. The chapter headings give an excellent idea of the scope of the volume: "Diseases of the Gastro-intestinal Tract," "Diseases of the Liver and Biliary Tract," "The Anaemias," "Diseases of the Blood, the Clotting Mechanism," "Hypertension," "Diseases of the Kidney and Genito-urinary Tract," "Adrenal Diseases," "Diseases of Iodine Metabolism," "Diseases of Bone and the Parathyroid Gland," "Diseases of the Nervous System," "Diseases of Muscle," "Diabetes Mellitus and Hypoglycaemia," "Disorders of Nutrition," "Miscellaneous Disorders of Metabolism: I. Some Abnormalities of Amino-acid and Haemoglobin Metabolism," "Miscellaneous Disorders of Metabolism: II. Connective Tissue Disorders," "Miscellaneous Disorders of Metabolism: III. Porphyrias," "Miscellaneous Disorders of Metabolism: IV. Haemochromatosis," "Miscellaneous Disorders of Metabolism: V. Glycogen Storage Diseases and Galactosaemia," "Miscellaneous Disorders of Metabolism: VI. Lipidoses," and "Disorders of the Reproductive Organs."

ROGER J. WILLIAMS

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Stress and Strain in Bones. Their relation to fractures and osteogenesis. F. Gaynor Evans. Thomas, Springfield, Ill., 1957. 245 pp. Illus. \$6.50.

In this short monograph the author has attempted to bring together most of the data, including his own extensive researches, pertaining to the mechanical behavior of various bones, the structural characteristics of bone as a tissue, and the relationship of these mechanical data to osteogenesis, fracture healing, and the production of fractures.

He has wisely included a simple and easily understood introductory chapter on the elementary principles of mechanics and stress analysis and a glossary of engineering terms at the end of the book. Nine of the 14 chapters (not including the introduction) are devoted to the mechanical behavior of bones and bone, including methods and mathematical analyses. The rest are devoted to the correlation of these data with biological phenomena.

Throughout the book the author has very carefully and critically evaluated the vast literature in the field and has correctly pointed out a number of errors, both in semantics and interpretation, which have been perpetuated for many years; in doing so he has done the field a distinct service. I believe, however, that the sections on the purely mechanical as-

pects of the problem could have been improved if the author had included a small section, with diagrams and illustrations, on the external force systems causing stress and strain in bone—that is, gravity, inertia, ground forces, and muscle forces—demonstrating how they produce stress and strain in bone. This is particularly true of muscle action, since failure to include the effect of muscle action vitiates much of the published data on the stress distribution, stress magnitude, and so forth, on intact long bones. Most of these tests have been carried out on statically or dynamically loaded femurs by means of one applied force—for example, on the head of the femur.

Since muscles act not only by increasing the magnitude but by changing the line of action of the resultant force, and exert their effects only between their origins and their insertions, the resultant stress distribution and the magnitude of the stress can be markedly altered. Static or dynamic tests, therefore, on firmly fixed femurs, for example, loaded through the femoral head, with the opposing force only at the tibial end, have very little in common with the actual distribution in the femur *in vivo*. The author is aware of this, since he included some of Pauwels' work on models, in which various braces were applied to simulate certain muscle actions, but I do not think he emphasizes sufficiently the deficiency of data collected on *in vitro* loading and the impossibility of correlating this with the actual conditions as they are *in vivo*. The studies of the author and his collaborators recording strain directly from living animals should make it possible, in the future, to circumvent a great many of these difficulties.

The mechanical data which the author has compiled from his own and other researches on the structural characteristics of various bones and on bone as a tissue should prove very valuable to workers concerned with the safety and tolerances of the human body under circumstances of mechanical stress (as in automobiles, airplanes, and so forth) and should help these groups in designing safer vehicles.

The section devoted to fracture production should prove valuable to orthopedic surgeons, particularly in the evaluation of the type of internal or external support to be used in immobilizing fractures and in protecting against the type of bone stress most likely to disrupt continuity of the opposed bone surfaces.

In the sections which will most interest biologists—those on the relationship between mechanical stress, osteogenesis, bone architecture, fracture healing, and so forth—the author is unavoidably hampered, not only by the lack

of previous critical experiments, but also by the fact that in the past the problem has not even been defined conceptually in terms of modern biology. Attempts to correlate trabecular orientation of spongy bone and computed or *in vitro* determined stress lines in models and intact long bones is quite naive, and this is well brought out by the author. Unfortunately, most of the literature in the past has focused on gross architectural changes such as trabecular pattern in spongy bone, but little has been done with ultrastructural changes in compact bone. For the most part, the experimental work in the past has not been very critical or conclusive. Most of these deficiencies are well discussed by the author, including the lack of any good suggestions about the mechanisms involved whereby mechanical stress alters bone architecture, healing, and so on. Again, I believe the author might have improved this section with some more pointed comments on the need to consider the biological effects of mechanical stress at various ultrastructural and structural levels. The orientation of collagen fibrils, primitive fibers, fibers, fiber bundles, and so forth may be quite different even in compact bone, and the reaction to mechanical stress at these different levels may be quite different. The same is true of the collagen in trabeculae. There may be no relationship between the orientation of the gross trabeculae, the orientation of the ultrastructural components of the trabeculae and their relative behavior to mechanical stress. If mechanical stress does affect the production and resorption of bone and the ultrastructural arrangement of the components of bone, it does so by physicochemical means not yet even defined conceptually, let alone demonstrated experimentally.

In his well-written monograph, Evans has, by assembling the data, critically evaluating them, and pointing up deficiencies in the biological approaches to this important problem, pointed the way, and this book should do much to stimulate more basic research in this field.

MELVIN J. GLIMCHER
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William Harvey. His Life and Times: His Discoveries: His Methods. Louis Chauvois. Philosophical Library, New York, 1957. 271 pp. Illus. \$7.50.

The celebrations of the tercentenary of William Harvey's death in 1957 may have motivated many to look for an adequate biography of the physician of Charles I, who made what is probably the greatest physiological discovery of all time. They will have discovered to their surprise that no recent work of this kind exists.

Louis Chauvois' book fills this gap quite well. It contains what the title promises. It gives a very scholarly and many-sided account of Harvey's times. It summarizes all the known data on Harvey, adding some that are new. Chauvois, a scientist himself, gives a very clear and original analysis of the scientific problems involved. His genuine enthusiasm for his hero is such an asset to the book that one gladly overlooks a few minor exaggerations, injustices, and omissions and gets used to a style the superlatives of which should sound better in French than in English.

ERWIN H. ACKERKNECHT

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Building an Engineering Career. Clement C. Williams and Erich A. Farber. McGraw-Hill, New York, ed. 3, 1957. x + 299 pp. Illus. \$4.75.

Some 30 or 40 years ago, the professors of electrical engineering decided that young electrical engineers ought to learn something about the science of illumination. After all, most modern lights were electric, weren't they? About the same time it was decided, also, that such students ought to learn something about electric railways because of their growing importance in transportation. Unfortunately, no one knew enough about either to construct a full 16-week semester course from his material. A compromise was, therefore, reached, in which a course in "Illumination and Electric Railways" was put together. This strange marriage of subject matter was copied by other schools, and eventually such a course appeared in many engineering catalogs. It has long since gone the way of courses in stereometry, for which we can all be thankful.

A new trend, one that is probably only 15 or 20 years old, is to teach a course on "what every young engineer ought to know." This course usually includes the history of engineering, an insight into the "engineering method" (some engineers still think they have a patent on quantitative thinking), a discussion on how and what to study, a preview of all engineering courses, a taste of ethics, and a glance into the future. Such things as how to get a job and how to run a slide rule are sometimes included, if the book doesn't get too thick and heavy.

This volume does not contain all these features but does contain most of them. It is divided into three major parts, the first of which is intended to tell the student how to get his education, and the second, to give him some historical background. The third, called "Engineering Achievements," (its purpose is not at all clear to me), recounts, almost in encyclopedia form, some of the wonders of engineer-

ing. Apparently this section is supposed to be a "come-on" to convince the student, while he is studying mathematics, physics, chemistry, English, and all the other subjects that seem to be only remotely connected with his engineering goal, that all is well, the faculty is not leading him astray, and eventually he, too, will design a bridge and rocket off to the moon.

There must now be dozens of little books aimed at guiding the student's first unsure steps toward professionalism. I have grave doubts that any of them really accomplish their purpose. There must be many good teachers who, early in their students' careers, inspire them and help them to see more clearly what they may accomplish in their four years at college. But this kind of inspiration is a personal thing, and any attempt to catch the full flavor in a written document is fraught with danger.

This little book, which was originally written by Clement C. Williams, an engineer who in his later years was president of Lehigh University, has been brought up to date, and certain new material has been added. It is a textbook that undoubtedly goes hand-in-hand with a series of lectures. It is not a book that may be expected to inspire the casual reader or the unguided student.

ERIC A. WALKER
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The Physiology of Fishes. vol. I. Metabolism. Margaret E. Brown, Ed. Academic Press, New York, 1957. xiii + 447 pp. Illus. \$12.

Young physiologists have often remarked to me that they were writing a physiology of fishes. Encouragement was never possible because of the tremendous difficulty of the venture. But the need for such a work has been increasing sharply in recent years, and volume I, *Metabolism*, of *The Physiology of Fishes*, by Margaret E. Brown and coauthors, is very welcome. It is no surprise that the contemplated single volume had to be published as two, or that the work is not a textbook in the teaching meaning of the term. If the work may be said to have a shortcoming, it is in the limited integration of such factual knowledge as is now available. Whether for printing economy or by choice of the authors, there is insufficient histology in the first volume.

Much more may be said in praise of the enterprise. An admirable group of authors were persuaded to participate, and the work clearly reflects the authority of its members. (As an aside it may be noted that the authors were drawn six from Great Britain, three from Canada, and one from the United States. To an

administrator in this wealthy country it is sobering to think that, in spite of the large number of workers engaged in practical fisheries in this country, perhaps we do not provide a proportionate number of leaders in so basic an area as physiology. But of more than 1000 basic literature citations, about 37 percent are from journals edited in the United States—a figure that is reassuring, though perhaps smaller than might be expected from the large sums of money spent here on fisheries research.)

From the first chapter, that by F. E. J. Fry on the aquatic respiration of fish, there emerges a truism that is generally borne out through the work. One might assume that greater complexity would always be encountered in a study of mammalian function than in that of piscine function. But, as is revealed in Fry's careful analysis, the metabolic rates of fishes must adapt over a wide range of environmental temperatures, and the additional parameter of temperature adaptation leads not to simplicity but to complexity. Similarly, the combination of gill respiration with gut, pharyngeal, and lung respiration, treated in a later chapter, reflects itself in the properties of the blood and the adaptations of the circulatory system. The subject of fish physiology is therefore revealed as being exceptionally challenging, and it is to be hoped that this valuable book will stimulate ever wider interest and activity in the subject.

Space will not permit description of individual chapters. Coupled with the chapters on the systems supporting metabolism are chapters on skin and scales, on development and hatching, and on growth. Volume II will present the nervous and sensory systems, behavior, and such special topics as electric organs, swimbladder, luminous organs, color changes, and physiological genetics. It may suffice, then, to say that the book will be required reading for all professional fisheries investigators, to whom the carefully selected bibliography alone will be worth the cost of the volume. In addition, the book is highly recommended to every student and scientist interested either in fish or in comparative physiology or biochemistry.

ARTHUR W. MARTIN
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A History of Industrial Chemistry. F. Sherwood Taylor. Abelard-Schuman, New York, 1957. xvi + 467 pp. Illus. + plates. \$7.50.

After an introductory summary, the author devotes about one-third of his book to the "prescientific" period and two-thirds to "the scientific chemical industries." The first part is an interesting survey of the older chemical industries,

presented in 11 chapters, divided according to subjects from metallurgy to fermentations, and illustrated by 34 figures and 10 plates, many of them containing two pictorial presentations, from a variety of sources. The second part, which brings the total number of figures to 62 and that of plates to 22, contains long chapters on the history of scientific chemistry and leaves insufficient space for discussion of the special industrial aspects. The author argues in the preface that he makes "no apology for the introduction of much that is ordinarily regarded as belonging to the history of chemical theory rather than to that of the industrial or applied aspects of the subject." No apology would have been necessary if he had shown the connections and influences between science and industry in their development. Instead, Taylor leaves the two parts quite separate. His history of chemical industries becomes a catalog of industrial chemicals. Very little is said about the methods of production or about equipment and materials of construction, and almost nothing is said about the many other sides of the chemical industry, such as organization, markets, size of production, or financial matters. Within these severe limitations, the author attempts to describe all groups of industrial chemicals and even includes a chapter on "The Road to Nuclear Power."

Scarcely any typographical errors and only a few errors of fact are to be found in Taylor's book. In some instances important names are omitted while others are given, and some condensations are so worded that they could be easily misunderstood.

An appendix, "not intended to be a bibliography of industrial chemistry," lists 227 publications suggested for further reading.

In spite of its shortcomings, Taylor's posthumous book may well stimulate greater interest in the history of an important part of our civilization.

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New Books

Managing Southern Soils. H. B. Van derford. Wiley, New York, 1957. 389 pp. \$4.75.

Flowering Trees in India. M. S. Randhawa. Indian Council of Agricultural Research, New Delhi, 1957. 209 pp. Rs. 15.

Symposium on Nutrition and Behavior. Nutrition Symposium Series, Number 14. National Vitamin Foundation, New York, 1957. 124 pp. \$2.50.

An Atlas of Fetal and Neonatal Histology. Marie A. Valdes-Dapena. Lippincott, Philadelphia, 1957. 209 pp. \$11.

Phenazines. G. A. Swan and D. G. I. Felton. Interscience, New York, 1957. 712 pp. \$22.50.

A Pictorial History of the American Indian. Oliver LaFarge. Crown, New York, 1957. 272 pp. \$7.50.

The Ancient Civilizations of Peru. J. Alden Mason. Penguin Books, Baltimore 11, Md. 350 pp. Paper, \$1.25.

The Order of Presentation in Persuasion. Carl I. Hovland and others. Yale University Press (for the Institute of Human Relations), New Haven; Oxford University Press, London, 1957. 202 pp. \$4.

First Symposium on Host Specificity among Parasites of Vertebrates. Institut de Zoologie, Université de Neuchâtel, Neuchâtel 7, Switzerland, 1957. 324 pp.

International Review of Cytology. vol. VI. G. H. Bourne and J. F. Danielli, Eds. Academic Press, New York, 1957. 566 pp. \$12.

Marine Electrical Practice. G. O. Watson; chapters by R. A. Harvey, R. V. Mills, H. R. Ruff. Philosophical Library, New York, 1957. 334 pp. \$12.

The Clinical Application of Antibiotics. vol. III, *Chloramphenicol and the Tetracyclines.* M. E. Florey. Oxford University Press, London, 1957. 402 pp.

A Basic Laboratory Course in College Chemistry. With supplementary exercises. J. F. Hazel. Wiley, New York, ed. 2, 1957. 241 pp. \$3.95.

Oxine and Its Derivatives. vol. I, *Oxine*, pt. 1; vol. II, *Oxine*, pt. 2; vol. III, *Derivatives of Oxine*, pt. 1; vol. IV, *Derivatives of Oxine*, pt. 2. R. G. W. Hollingshead. Butterworths, London; vols. I and II, 1954; vols. III and IV, 1956. 1211 pp. \$8.50 per volume.

Handbuch der Physik. vol. 39, *Structure of Atomic Nuclei.* S. Flügge, Ed. Springer, Berlin, 1957. 571 pp. DM. 125.

Host-Parasite Relationships in Living Cells. A symposium. Sponsored by the James W. McLaughlin Fellowship Program, University of Texas, Medical Branch, 27 Apr. 1956. Compiled and edited by Harriet M. Felton. Thomas, Springfield, Ill., 1957. 264 pp. \$6.50.

The Chronically Ill. Joseph Fox. Philosophical Library, New York, 1957. 248 pp. \$3.95.

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Principles of the Properties of Materials. Jacob Porter Frankel. McGraw-Hill, New York, 1957. 242 pp. \$6.

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Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, but to the publisher or agency sponsoring the publication.)

The Early Development of Rana Capito Sevosa. Tulane Studies in Zoology, vol. 5, No. 9. E. Peter Volpe. 19 pp. \$0.35. *Variation and Subspecies of the Crawfish Orconectes Palmeri (Faxon) (Decapoda, Astacidae).* vol. 5, No. 10. George Henry Penn. 32 pp. \$0.60. *Christo-Paganism.* A study of Mexican religious syncretism. Preprinted from Publ. 19, Middle American Research Institute. William Madsen. 76 pp. Tulane University, New Orleans, 1957.

International Geophysical Year 1957-1958, Meteorological Data Centre. Report No. 7. *Microcards of IGY Meteorological Data.* World Health Organization, Geneva, 1957.

Commemorative Symposium. Twentieth anniversary of the National Cancer Institute. *Journal of the National Cancer Institute,* vol. 19, No. 2. 216 pp. \$2. *Bibliography of Medical Reviews.* vol. 2, 1957. National Library of Medicine. 111 pp. \$0.60. U.S. Public Health Service, Washington, 1957 (order from Supt. of Documents, GPO, Washington 25).

Electric Hygrometers. NBS Circular 586. Arnold Wexler. U.S. National Bureau of Standards, Washington 25, 1957 (order from Supt. of Documents, GPO, Washington 25). 21 pp. \$0.20.

Financial Aid for College Students: Graduate. Bulletin 1957 No. 17. Richard C. Mattingly. 151 pp. \$0.50. *Careers in Atomic Energy.* Pamphlet No. 119. Walter J. Greenleaf. 36 pp. \$0.25. *Faculty in Institutions of Higher Education.* November 1955. Circular No. 504. M. Clemens Johnson and Leah W. Ramsey. 40 pp. \$0.30. U.S. Office of Education, Washington 25, 1957 (order from Supt. of Documents, GPO, Washington 25).

Selected Bibliography: Fatigue, Stress, Body Change and Behavior. WADC Technical Rept. 57-125. ASTIA Document No. AD 118091. William Bevan and Rollin M. Patton. Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, 1957 (order from ASTIA Documents Service, Knott Building, Dayton 2, Ohio). 64 pp.

Anatomy and Taxonomy of the Mature Naiads of the Dragonfly Genus Plathemis (Family Libellulidae). Smithsonian Miscellaneous Collections, vol. 134, No. 11. Harvey R. Levine. 28 pp. *A New Species of Calanopia (Copepoda: Calanoida) from the Caribbean Sea.* Proceedings of the U.S. National Museum, vol. 107, No. 3382. Thomas E. Bowman. 7 pp. Smithsonian Institution, Washington 25, 1957.

An Archaeological Survey of West Central New Mexico and East Central Arizona. Papers of the Peabody Museum of Archaeology and Ethnology, vol. XLIV, No. 1. Deward Bridge Danson. Peabody Museum, Cambridge, Mass., 1957. 133 pp.

Research for Life. A report from the Jackson Laboratory. 33 pp. *Roscoe B. Jackson Memorial Laboratory, Twenty-eighth Annual Report, 1956-1957.* 76 pp. Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Me., 1957.

International Zoological Congress

The National Science Foundation, the American Institute of Biological Sciences, and the American Society of Zoologists are cooperating to support the travel of a limited number of American scientists to the 15th International Zoological Congress, to be held in London, England, 15-23 July 1958. Grants will not normally exceed \$500. Application blanks are available from the A.I.B.S., 2000 P Street, NW, Washington 6, D.C., and completed forms must be returned to the A.I.B.S. no later than 1 January 1958.

Any active American zoologist, regardless of his society affiliations, is eligible. A portion of the funds available will be used to support the travel of qualified younger investigators who have not had the opportunity to attend an international congress.

Congress for Psychiatry

Zurich, Switzerland, from Sept. 1 to 7, was host to the second International Congress for Psychiatry, which had been organized by Manfred Bleuler for the Swiss Psychiatric Association and sponsored jointly by many other groups.

The keynote of the conference was the "present state of our knowledge about the group of schizophrenias." Representatives from such countries as Ghana, Thailand, Malaya, and Yugoslavia, and from the entire Western world, presented papers. Since an invitation to Soviet scientists had been withdrawn by the Swiss, following the Hungarian disaster, there was no Russian presentation.

Almost from the first, the ancient conflict of "nature versus nurture," which has bubbled around the issues of schizophrenia and others in human behavior, was rejuvenated and became the true center of the conference. The discussion was partitioned into several main categories. The inherited nature of schizophrenia was argued by, among others, F. J. Kallmann, T. Slater, and T. Sjoegren; the role of biochemical influences was presented by D. Richter and M. Buscaino; that of the anthropological influences, by L. Van der Horst; of the environmental and familial influences, by T. Lidz and G. Bally.

E. Stransky discussed the history of the concept of schizophrenia; L. Binswanger, the role of existential analysis; J. Delay, the Rorschach test and the family; H. Ey, the classification of schizophrenia; W. H. Gantt, experimental psychoses; L. B. Kalinowsky, electroshock and drugs; A. Lewis, rehabilitation of schizophrenics; L. Kanner, aspects of childhood schizophrenia; D. E. Cameron, de patterning of chronic paranoid; P. H. Hoch, pseudoneurotic schizophrenia and lysergic acid diethylamide; J. Zubin, prognosis in schizophrenia; H. Osmond, history of chemical concepts; A. Cerletti, lysergic acid diethylamide; H. Baruk, the chemical causes of experimental catonia and treatment; H. Hoagland, unspecific stress and endocrine derangement; A. S. Marrazzi, cerebral synaptic transmission; R. G. Heath, metabolic abnormalities; C. P. Richter, rhythm of behavior and endocrine function.

D. Shakow discussed normalization trends in chronic schizophrenics; Ø. Ødegaard, ecological aspects; N. D. C. Lewis, psychiatric terminology; H. Delgado, schizophrenic delusion; I. Matte-Blanco, schizophrenic thinking and symbolic logic; S. Rado, deficiency theory; and D. E. Wittkower, need gratification. K. M. Bowman commented on the pathophysiology. There were, as well, many other contributions in theoretical, diagnostic, and therapeutic approaches.

One of the highlights of the conference was the paper by C. G. Jung, who, along with Eugen Bleuler and his son, Manfred, has done so much to make Switzerland important in psychiatry.

In an imposing symposium organized by N. Kline, which included, among others, V. Kinross-Wright, M. Shepherd, W. Mayer-Gross, and F. Freyhan, the present status of the tranquilizers and other drugs was discussed. It was the consensus that there was an increasing clarity about the limitations of our present pharmacotherapeutic agents in treating the majority of hospitalized patients.

Social psychiatry, which is still in its formative phases, provided a second theme, of growing importance. The experiments of Carstairs in England, Sivadon in France, and many others, both on the Continent and in the United States, promised a new approach in such areas as work therapy and social engineering.

Several studies discussed the meaning of the term *schizophrenia* itself and its usefulness as a classification. Many theoretical formulations were offered indicating that we are either dealing with a number of processes or have yet some way to go in defining the central one.

Many social activities and clinic visits were conducted for the congress participants. Plans for publication of papers had not been finally concluded before the congress ended.

As Bleuler aptly said at the congress dinner in summing up his efforts, he felt that he had "at least provided a conference where anyone could say whatever he thought." In this respect, certainly the conference was a significant success.

JORDAN M. SCHER

Northwestern University

Nuclear Reactors in Biomedical Research

A Biomedical Advisory Committee has been formed to encourage the biological and medical uses of the reactor at Massachusetts Institute of Technology and to exercise control over its use in the treatment of human patients. Since the reactor will go into operation early in 1958, the committee believes that prospective users would welcome an opportunity to see it and to become familiar with the kinds of research in biology and medicine which can be done with the aid of the reactor.

For these purposes the committee is sponsoring a Symposium on the Use of Nuclear Reactors in Biomedical Research at M.I.T. on 3 December. Additional information regarding this symposium may be obtained from Dr. C. J. Maletskos, Medical Department, Massachusetts Institute of Technology, Cambridge 39, Mass.

Forthcoming Events

December

4-8. American Psychoanalytic Assoc., New York, N.Y. (J. N. McVeigh, APA, 36 W. 44 St., New York 36.)

4-10. American Acad. of Optometry, annual, Chicago, Ill. (C. C. Koch, 1506-1508 Foshay Tower, Minneapolis 2, Minn.)

5-7. Texas Acad. of Science, annual, Dallas. (G. C. Parker, Education Dept., Texas A&M College, College Station.)

5-8. American College of Cardiology, 6th interim, Cincinnati, O. (P. Reichert, ACC, Empire State Bldg., New York 1.)

6-7. Oklahoma Acad. of Science, annual, Enid. (J. T. Self, Dept. of Zoology, Univ. of Oklahoma, Norman.)

7-8. American Acad. of Dental Medi-

cine, New York, N.Y. (S. Ross, 136 E. 36th St., New York 16.)

8-11. American Inst. of Chemical Engineers, annual, Chicago, Ill. (F. J. Van Antwerpen, AIChE, 25 W. 45 St., New York 36.)

9-11. Fluorides Symp., Cincinnati, Ohio. (Secretary, Inst. of Industrial Health, Kettering Laboratory, Eden and Bethesda Aves., Cincinnati 19.)

9-13. Eastern Joint Computer Conf., Washington, D.C. (H. H. Goode, Dept. of Electrical Engr., Univ. of Michigan, Ann Arbor.)

9-22. Southeast Asia Soil Science Conf., 1st, Manila, Philippines. (I. G. Valencia, Bureau of Soils, P.O. Box 1848, Manila.)

10-11. Water Quality Control for Sub-surface Injection, 2nd annual conf., Nor-

man, Okla. (M. L. Powers, Extension Div., Univ. of Oklahoma, Norman.)

13-14. Association for Research in Nervous and Mental Disease, 37th annual, New York, N.Y. (R. J. Masselink, 700 W. 168 St., New York 32.)

15-18. American Soc. of Agricultural Engineers, Chicago, Ill. (J. L. Butt, ASAE, St. Joseph, Mich.)

16-18. Air Traffic Control Symp., Philadelphia, Pa. (Air Traffic Symp., Franklin Inst. Labs., 20th St. and Parkway, Philadelphia 3.)

17-19. Nuclear Sizes and Density Distributions Conf., Stanford, Calif. (R. Hofstadter, Stanford Univ., Stanford, Calif.)

19-21. American Physical Soc., Stanford, Calif. (W. A. Nierenberg, Univ. of California, Berkeley 4.)

26-27. Northwest Scientific Assoc., annual, Spokane, Wash. (W. B. Merriam, Geography Dept., State College of Washington, Pullman.)

26-30. American Assoc. for the Advancement of Science, annual, Indianapolis, Ind. (R. L. Taylor, AAAS, 1515 Massachusetts Ave., NW, Washington 5.)

27. Association for Symbolic Logic, Cambridge, Mass. (J. Barlaz, Rutgers Univ., New Brunswick, N.J.)

27-28. Linguistic Soc. of America, Chicago, Ill. (A. A. Hill, Box 7790, University Station, Austin 12, Tex.)

27-30. American Finance Assoc., annual, Philadelphia, Pa. (G. E. Hassett, Jr., New York Univ., 90 Trinity Pl., New York 6.)

28-29. American Folklore Soc., annual, Chicago, Ill. (M. Leach, Box 5, Bennett Hall, Univ. of Pennsylvania, Phila. 4, Pa.)

28-30. American Anthropological Assoc., annual, Chicago, Ill. (W. S. Godfrey, Jr., Logan Museum, Beloit College, Beloit, Wis.)

28-30. American Economic Assoc., annual, Philadelphia, Pa. (J. W. Bell, Northwestern Univ., Evanston, Ill.)

28-30. Archaeological Inst. of America, annual, Washington, D.C. (C. Boulter, 608, Univ. of Cincinnati Library, Cincinnati 21, Ohio.)

28-30. Econometric Soc., Philadelphia, Pa. (R. Ruggles, Dept. of Economics, Yale Univ., New Haven, Conn.)

28-30. History of Science Soc., annual, New York, N.Y. (Miss M. Boas, Brandeis Univ., Waltham 54, Mass.)

January

6-8. Reliability and Quality Control, 4th natl. symp., Washington, D.C. (C. M. Ryerson, RCA, Bldg. 10-6, Camden 2, N.J.)

7-10. Radioactive Isotopes in Clinical Application and Research, 3rd internat. symp., Bad Gastein, Austria. (Second Medical Clinic, Vienna Univ., Vienna, Austria.)

8-10. Northeastern Weed Control Conf., 12th annual, New York. (R. J. Aldrich, Farm Crop Dept., Rutgers Univ., New Brunswick, N.J.)

13-17. Society of Automotive Engineers, annual, Detroit, Mich. (Meetings Div., SAE, 29 W. 39 St., New York 18.)

22-24. American Council of Learned Societies, 39th annual, Bloomington, Ind. (ACLS, 2101 R St., NW, Washington 8.)

22-25. American Group Psychotherapy Assoc., 15th annual, New York. (M. Berger, 50 E. 72 St., New York 21.)

27-28. Scintillation Counter Symp., Washington, D.C. (G. A. Morton, Radio Corporation of America, Princeton, N.J.)

27-29. American Soc. of Heating and Air-Conditioning Engineers, Pittsburgh, Pa. (A. V. Hutchinson, ASHAE, 62 Worth St., New York 13.)

27-30. American Meteorological Soc., 163rd natl., New York. (K. C. Spengler, AMS, 3 Joy St., Boston 8, Mass.)

27-31. Institute of Aeronautical Sciences, 26th annual, New York. (S. P. Johnston, IAS, 2 E. 64 St., New York 21.)

28-30. Aging, 4th Ciba Foundation Colloquium (by invitation), London, England. (G. E. W. Wolstenholme, 41 Portland Pl., London, W.1.)

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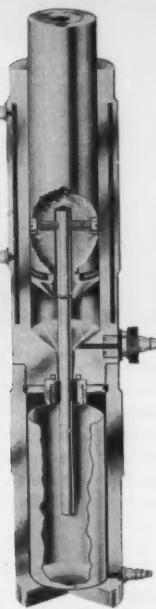
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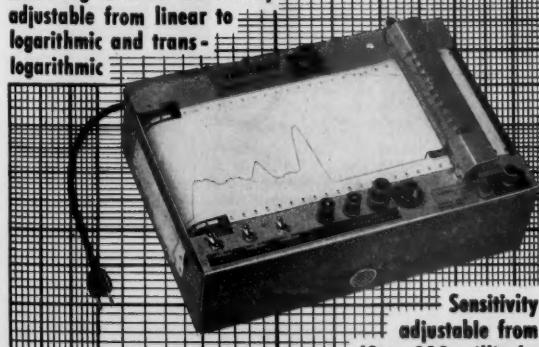
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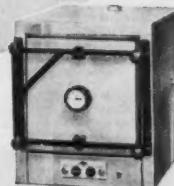
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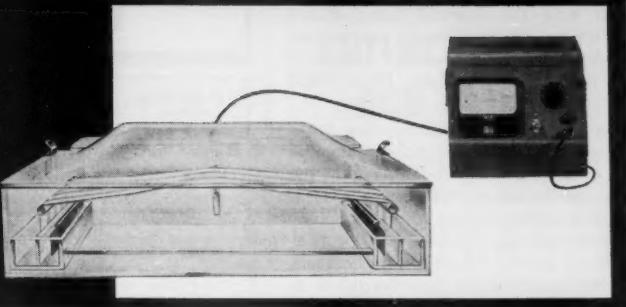
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■ ELECTROPOLISHER for preparation of metallographic specimens consists of a drive assembly, an electrolyte tank, and a pump assembly. Electrolyte tanks can be interchanged. All parts of the tank and pump are fabricated of polyvinyl chloride. The pump is driven magnetically through the bottom of the tank. Sample area is controlled by interchangeable masks from 5/16 to 3/4 in. in diameter. Electrolyte is pumped up against the sample. A separately housed power source provides a-c and d-c power. (Buehler Ltd., Dept. S718)

■ PARTITIONING AGENTS for gas and vapor-phase chromatography consist of a granular, inert carrier uniformly coated in a film thickness dictated by experience. Twenty-eight different coating films are available. Ten solid adsorbents are also offered. The inert carrier used in preparing the ready-to-use partitioning adsorbents can be furnished uncoated. (Burrell Corporation, Dept. S719)

■ VARIABLE-SPEED SHAKER is particularly adapted to shaking stoppered test tubes and vessels under pressure. Rocker-type motion may be varied from 25 to 45 cy/min. Tube holders and clamps slide in 12 aluminum tracks. Each track can accommodate two tubes up to 8 in. long, or one longer tube. An explosion-proof motor providing a single speed of 35 cy/min can be furnished. (Laboratory Glass and Instruments Corp., Dept. S726)

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National Bureau of Standards

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Inquiries should be addressed to:

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4. Programs of the more than 60 participating societies.
5. The Special Sessions: AAAS, Academy Conference, Conference on Scientific Manpower, National Geographic Society, Phi Beta Kappa, Sigma Xi-RESA.
6. Details of the Murat Temple—center of the Meeting—and of the hotels and other session sites.
7. Titles of the latest foreign and domestic scientific films to be shown in the AAAS Science Theatre.
8. Exhibitors in the 1957 Annual Exposition of Science and Industry and descriptions of their exhibits.

Directory content

1. AAAS officers, staff, committees for 1957.
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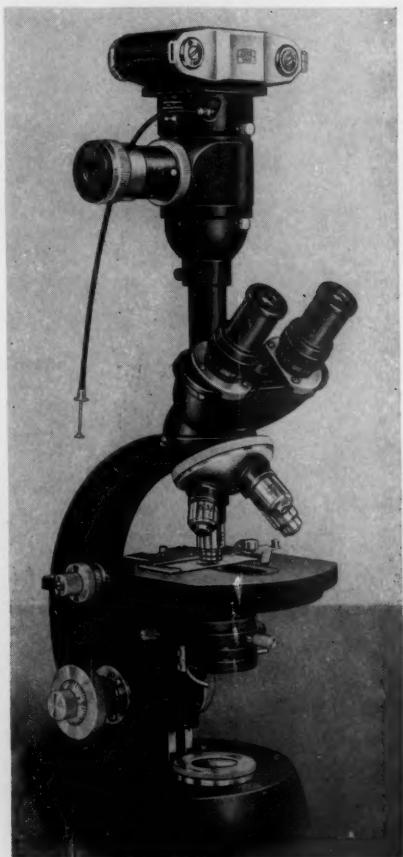
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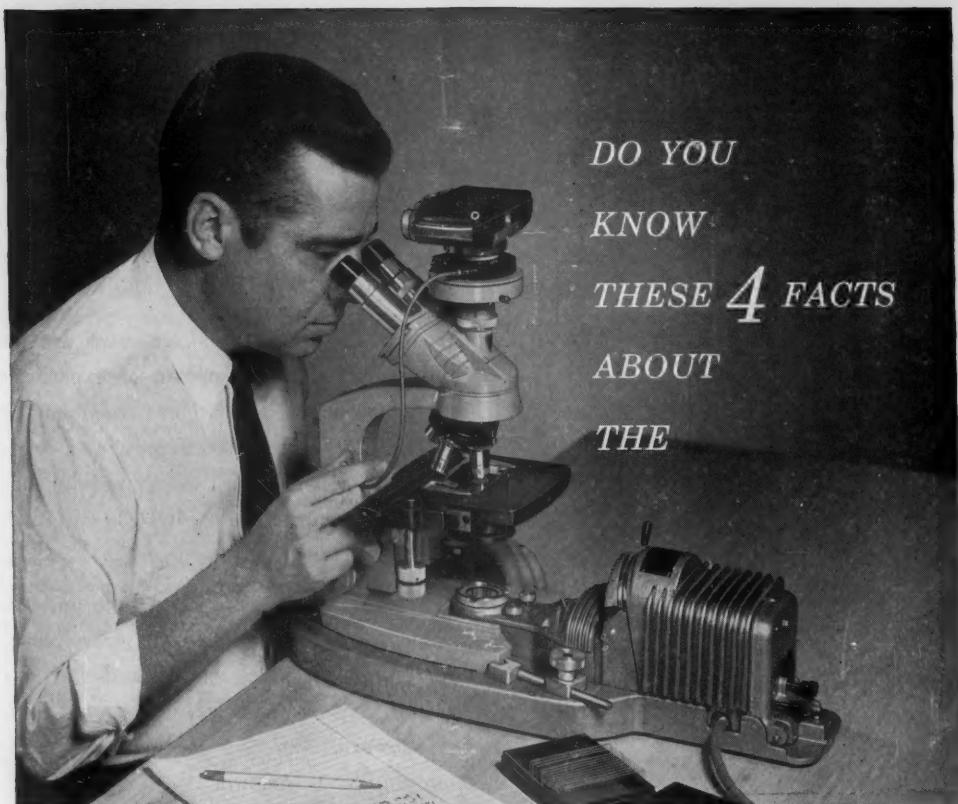
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